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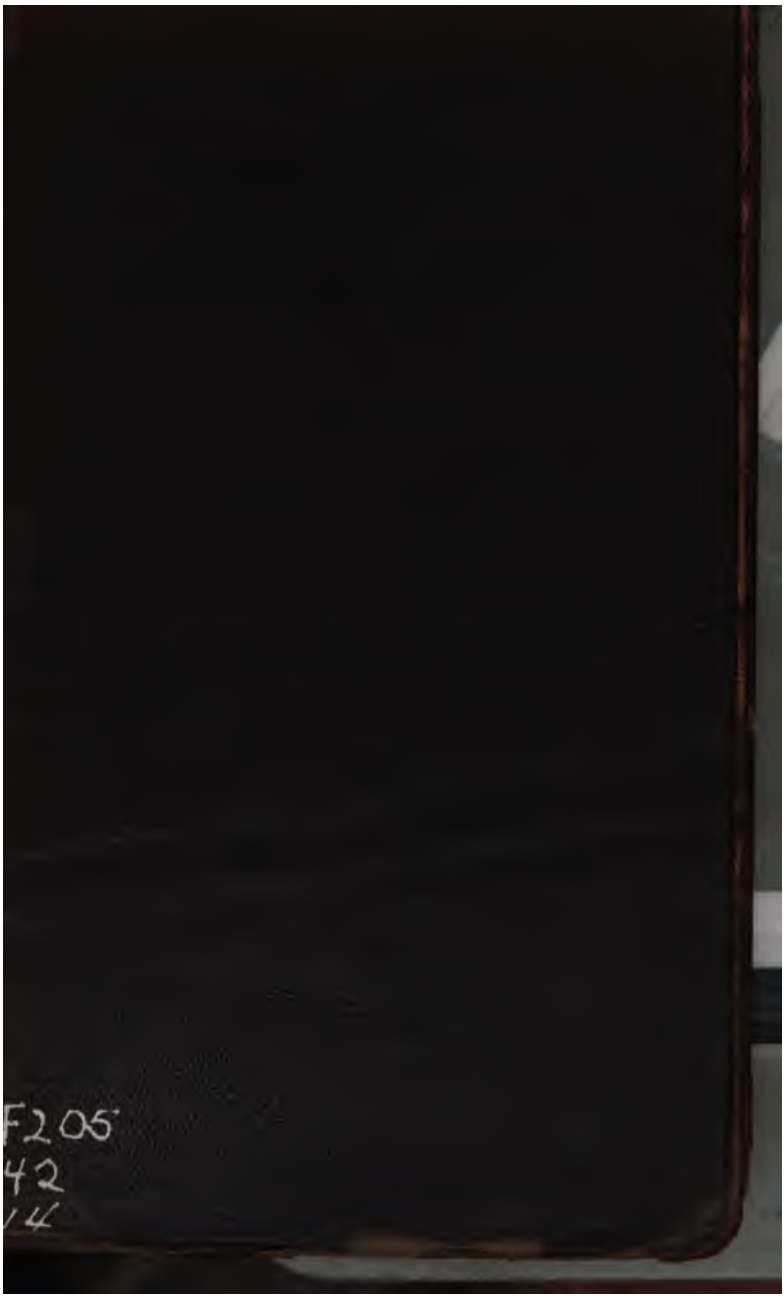
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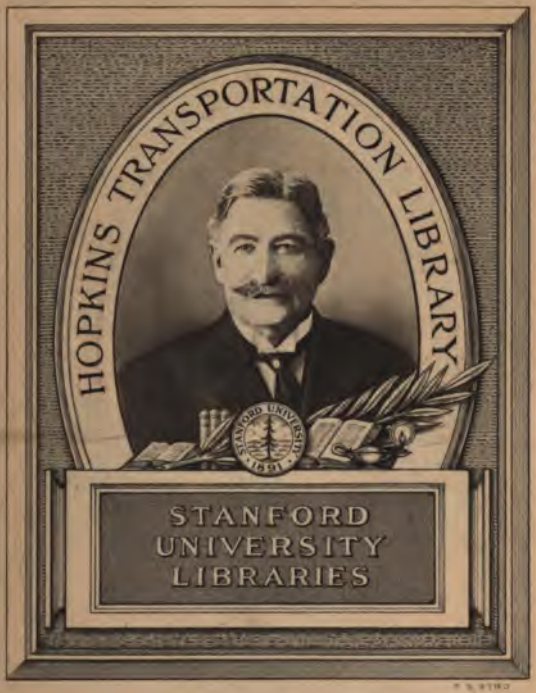

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RAILROAD CURVES

AND

EARTHWORK

BY

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FIFTH EDITION, REVISED

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PREFACE.

This book was prepared for the use of the students in the author's classes. It has been used in lithographed sheets for a number of years in very nearly the present form, and has given satisfaction sufficient to suggest putting it in print. An effort has been made to have the demonstrations simple and direct, and special care has been given to the arrangement and the typography, in order to secure clearness and conciseness of mathematical statement. Much of the material in the earlier part of the book is necessarily similar to that found in one or more of several excellent field books, although the methods of demonstration are in many cases new. This will be found true especially in Compound Curves, for which simple treatment has been found quite possible. New material will be found in the chapters on Turnouts and on "Y" Tracks and Crossings. The Spiral Easement Curve is treated originally. The chapters on Earthwork are essentially new; they include Staking Out; Computation, directly and with Tables and Diagrams; also Haul, treated ordinarily and by Mass Diagram. Most of the material relating to Earthwork is not elsewhere readily available for students' use.

The book has been written especially to meet the needs of students in engineering colleges, but it is probable that it will be found useful by many engineers in practice. The size of page allows it to be used as a pocket book in the field. It is difficult to avoid typographical and clerical errors; the author will consider it a favor if he is notified of any errors found to exist.

C. FRANK ALLEN.

Boston,
September, 1899.

PREFACE TO FIFTH EDITION

THE revision of this edition has been extensive. Few pages dealing with curves have escaped some change. In considerable part it has been a matter of refining or clearing up points shown by teaching to admit of improvement. A considerable amount of new material has been added and a few less important problems omitted; by rearrangement, and condensation in places, the size of the book has not been appreciably increased. The chapter on Turnouts has been almost completely rewritten; railroad practice in Turnouts has progressed materially in late years and complete revision of this chapter seemed advisable. The chapter on Connecting Tracks and Crossings has been materially extended. The chapter on Spirals has largely been rewritten and adapted to the use of the Spiral of the American Railway Engineering Association, the merits of which appeal to the author aside from the official sanction which establishes it as standard. A few, but not many, important changes have been made in the chapters on Earthwork.

It is still true that while this text was prepared primarily for students, nevertheless this book has proved to be well adapted to the requirements of the practicing railroad engineer or other engineer who has to deal with curves or with earthwork computation.

C. FRANK ALLEN.

January, 1914.

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RAILROAD CURVES AND EARTHWORK.

CHAPTER I.

1. The operations of "locating" a railroad, as commonly practiced in this country, are three in number: —

I. Reconnoissance.
II. Preliminary Survey.
III. Location Survey.

I. RECONNOISSANCE.

2. The Reconnoissance is a rapid survey, or rather a critical examination of country, without the use of the ordinary instruments of surveying. Certain instruments, however, are used, the Aneroid Barometer, for instance. It is very commonly the case that the termini of the railroad are fixed, and often intermediate points also. It is desirable that no unnecessary restrictions as to intermediate points should be imposed on the engineer to prevent his selecting what he finds to be the best line, and for this reason it is advisable that the reconnoissance should, where possible, precede the drawing of the charter.

3. The first step in reconnoissance should be to procure the best available maps of the country; a study of these will generally furnish to the engineer a guide as to the routes or section of country that should be examined. If maps of the United States Geological Survey are at hand, with contour lines and other topography carefully shown, the reconnoissance can be largely determined upon these maps. Lines clearly impracticable will be thrown out, the maximum grade closely determined, and the field examinations reduced to a minimum No

route should be accepted finally from any such map, but a careful field examination should be made over the routes indicated on the contour maps. The examination, in general, should cover the general section of country, rather than be confined to a single line between the termini. A straight line and a straight grade from one terminus to the other is desirable, but this is seldom possible, and is in general far from possible. If a single line only is examined, and this is found to be nearly straight throughout, and with satisfactory grades, it may be thought unnecessary to carry the examination further. It will frequently, however, be found advantageous to deviate considerably from a straight line in order to secure satisfactory grades. In many cases it will be necessary to wind about more or less through the country in order to secure the best line. Where a high hill or a mountain lies directly between the points, it may be expected that a line around the hill, and somewhat remote from a direct line, will prove more favorable than any other. Unless a reasonably direct line is found, the examination, to be satisfactory, should embrace all the section of intervening country, and all feasible lines should be examined.

4. There are two features of topography that are likely to prove of especial interest in reconnoissance, *ridge lines* and *valley lines.*

A *ridge line* along the whole of its course is higher than the ground immediately adjacent to it on each side. That is, the ground slopes downward from it to both sides. It is also called a *watershed line.*

A *valley line*, to the contrary, is lower than the ground immediately adjacent to it on each side. The ground slopes upward from it to both sides. Valley lines may be called *watercourse lines.*

A *pass* is a place on a ridge line lower than any neighboring points on the same ridge. Very important points to be determined in reconnoissance are the passes where the ridge lines are to be crossed; also the points where the valleys are to be crossed; and careful attention should be given to these points. In crossing a valley through which a large stream flows, it may be of great importance to find a good bridge crossing. In some cases where there are serious difficulties in crossing a ridge, a tunnel may be necessary. Where such structures, either

bridges or tunnels, are to be built, favorable points for their construction should be selected and the rest of the line be compelled to conform. In many parts of the United States at the present time, the necessity for avoiding grade crossings causes the crossings of roads and streets to become governing points of as great importance as ridges and valleys.

5. There are several purposes of reconnoissance: first, to find whether there is any satisfactory line between the proposed termini; second, to establish which of several lines is best; third, to determine approximately the maximum grade necessary to be used; fourth, to report upon the character or geological formation of the country, and the probable cost of construction depending somewhat upon that; fifth, to make note of the existing resources of the country, its manufactures, mines, agricultural or natural products, and the capabilities for improvement and development of the country resulting from the introduction of the railroad. The report upon reconnoissance should include information upon all these points. It is for the determination of the third point mentioned, the rate of maximum grade, that the barometer is used. Observing the elevations of governing points, and knowing the distances between those points, it is possible to form a good judgment as to what rate of maximum grade to assume.

6. The Elevations are usually taken by the *Aneroid Barometer.* Tables for converting barometer readings into elevations above sea-level are readily available and in convenient form for field use. (See Table XI., Allen's Field and Office Tables.)

Distances may be determined with sufficient accuracy in many cases from the map, where a good one exists. Where this method is impossible or seems undesirable, the distance may be determined in one of several different ways. When the trip is made by wagon, it is customary to use an *Odometer*, an instrument which measures and records the number of revolutions of the wheel to which it is attached, and thus the distance traveled by the wagon. There are different forms of odometer. In its most common form, it depends upon a hanging weight or pendulum, which is supposed to hold its position, hanging vertical, while the wheel turns. The instrument is attached to the wheel between the spokes and as near to the hub as practicable. At low speeds it registers accurately; as the

speed is increased, a point is reached where the centrifugal force neutralizes or overcomes the force of gravity upon the pendulum, and the instrument fails to register accurately, or perhaps at high speeds to register at all. If this form of odometer is used, a clear understanding should be had of the conditions under which it fails to correctly register. A theoretical discussion might closely establish the point at which the centrifugal force will balance the force of gravity. The wheel striking against stones in a rough road will create disturbances in the action of the pendulum, so that the odometer will fail to register accurately at speeds less than that determined upon the above assumption.

A cyclometer, manufactured for automobile use, is connected both with the wheel and the axle, and so measures positively the relative motion between the wheel and axle, and this ought to be reliable for registering accurately. Many engineers prefer to count the revolutions of the wheel themselves, tying a rag to the wheel to make a conspicuous mark for counting.

When the trip is made on foot, pacing will give satisfactory results. An instrument called the *Pedometer* registers the results of pacing. As ordinarily constructed, the graduations read to quarter miles, and it is possible to estimate to one-tenth that distance. Pedometers are also made which register paces. In principle, the pedometer depends upon the fact that, with each step, a certain shock or jar is produced as the heel strikes the ground, and each shock causes the instrument to register. Those registering miles are adjustable to the length of pace of the wearer.

If the trip is made on horseback, it is found possible to get good results with a steady-gaited horse, by first determining his rate of travel and figuring distance by the time consumed in traveling. Excellent results are said to have been secured in this way.

7. It is customary for engineers not to use a compass in reconnoissance, although this is sometimes done in order to trace the line traversed upon the map, and with greater accuracy. A pocket level will be found useful. The skillful use of pocket instruments will almost certainly be found of great value to the engineer of reconnoissance.

It may, in cases, occur that no maps of any value are in existence or procurable. It may be necessary, in such a case, to make a rapid instrumental survey, the measurements being taken either by pacing, chain, or stadia measurements. This is, however, unusual.

8. The preliminary survey is based upon the results of the reconnoissance, and the location upon the results of the preliminary survey. The reconnoissance thus forms the foundation upon which the location is made. Any failure to find a suitable line and the best line constitutes a defect which no amount of faithfulness in the later work will rectify. The most serious errors of location are liable to be due to imperfect reconnoissance; an inefficient engineer of reconnoissance should be avoided at all hazards. In the case of a new railroad, it would, in general, be proper that the Chief Engineer should in person conduct this survey. In the case of the extension of existing lines, this might be impracticable or inadvisable, but an assistant of known responsibility, ability, and experience should in this case be selected to attend to the work.

CHAPTER II.

II. PRELIMINARY SURVEY.

9. The Preliminary Survey is based upon the results of the reconnoissance. It is a survey made with the ordinary instruments of surveying. Its purpose is to fix and mark upon the ground a first trial line approximating as closely to the proper final line as the difficulty of the country and the experience of the engineer will allow; further than this, to collect data such that this survey shall serve as a basis upon which the final Location may intelligently be made. In order to approximate closely in the trial line, it is essential that the maximum grade should be determined or estimated as correctly as possible, and the line fixed with due regard thereto.

It will be of value to devote some attention here to an explanation about Grades and "Maximum Grades."

10. Grades. — The ideal line in railroad location is a straight and level line. This is seldom, if ever, realized. When the two termini are at different elevations, a line straight and of uniform grade becomes the ideal. It is commonly impossible to secure a line of uniform grade between termini. In operating a railroad, an engine division will be about 100 miles, sometimes less, often more. In locating any 100 miles of railroad, it is almost certain that a uniform grade cannot be maintained. More commonly there will be a succession of hills, part of the line up grade, part down grade. Sometimes there will be a continuous up grade, but not at a uniform rate. With a uniform grade, a locomotive engine will be constantly exerting its maximum pull or doing its maximum work in hauling the longest train it is capable of hauling; there will be no power wasted in hauling a light train over low or level grades upon which a heavier train could be hauled. Where the grades are not uniform, but are rising or falling, or rising irregularly, it will be found that the topography on some particular 5 or 10

miles is of such a character that the grade here must be steeper than is really necessary anywhere else on the line; or there may be two or three stretches of grade where about the same rate of grade is necessary, steeper than elsewhere required. The steep grade thus found necessary at some special point or points on the line of railroad is called the "Maximum Grade" or "Ruling Grade" or "Limiting Grade," it being the grade that limits the weight of train that an engine can haul over the whole division. It should then be the effort to make the rate of maximum grade as low as possible, because the lower the rate of the maximum grade, the heavier the train a given locomotive can haul, and because it costs not very much more to haul a heavy train than a light one. The maximum grade determined by the reconnoissance should be used as the basis for the preliminary survey. How will this affect the line? Whenever a hill is encountered, if the maximum grade be steep, it may be possible to carry the line straight, and over the hill; if the maximum grade be low, it may be necessary to deflect the line and carry it around the hill. When the maximum grade has been once properly determined, if any saving can be accomplished by using it rather than a grade less steep, the maximum grade should be used. It is possible that the train loads will not be uniform throughout the division. It will be advantageous to spend a small sum of money to keep any grade lower than the maximum, in view of the *possibility* that at this particular point the train load will be heavier than elsewhere on the division. Any saving made will in general be of one or more of three kinds:—

a. Amount or "quantity" of excavation or embankment;

b. Distance;

c. Curvature.

11. In some cases, a satisfactory grade, a low grade for a maximum, can be maintained throughout a division of 100 miles in length, with the exception of 2 or 3 miles at one point only. So great is the value of a low maximum grade that all kinds of expedients will be sought for, to pass the difficulty without increasing the rate of maximum grade, which we know will apply to the whole division.

12. Sometimes by increasing the length of line, we are able to reach a given *elevation with* a lower rate of grade. Some-

times heavy and expensive cuts and fills may serve the purpose. Sometimes all such devices fail, and there still remains necessary an increase of grade at this one point, but at this point only. In such case it is now customary to adopt the higher rate of grade for these 2 or 3 miles and operate them by using an extra or additional engine. In this case, the "ruling grade" for the division of 100 miles is properly the "maximum grade" prevailing over the division generally, the higher grade for a few miles only being known as an "Auxiliary Grade" or more commonly a "Pusher Grade." The train which is hauled over the engine division is helped over the auxiliary or pusher grade by the use of an additional engine called a "Pusher." Where the use of a short "Pusher Grade" will allow the use of a low "maximum grade," there is evident economy in its use. The critical discussion of the importance or value of saving distance, curvature, rise and fall, and maximum grade, is not within the scope of this book, and the reader is referred to Wellington's "Economic Theory of Railway Location."

13. The Preliminary Survey follows the general line marked out by the reconnoissance, but this rapid examination of country may not have fully determined which of two or more lines is the best, the advantages may be so nearly balanced. In this case two or more preliminary surveys must be made for comparison. When the reconnoissance has fully determined the general route, certain details are still left for the preliminary survey to determine. It may be necessary to run two lines, one on each side of a small stream, and possibly a line crossing it several times. The reconnoissance would often fail to settle minor points like this. It is desirable that the preliminary survey should closely approximate to the final line, but it is not important that it should fully coincide anywhere.

An important purpose of the "preliminary" is to provide a map which shall show enough of the topography of the country, so that the Location proper may be projected upon this map. Working from the line of survey as a base line, measurements should be taken sufficient to show streams and various natural objects as well as the contours of the surface.

14. The Preliminary Survey serves several purposes: —

First. To fix accurately the maximum grade for use in Location.

Second. To determine which of several lines is best.

Third. To provide a map as a basis upon which the Location can properly be made.

Fourth. To make a close estimate of the cost of the work.

Fifth. To secure, in certain cases, legal rights by filing plans.

15. It should be understood that the preliminary survey is, in general, simply a means to an end, and rapidity and economy are desirable. It is an instrumental survey. Measurements of distance are taken usually with the chain, although a tape is sometimes used. Angles are taken generally with a transit; some advocate the use of a compass. The line is ordinarily run as a broken line with angles, but is occasionally run with curves connecting the straight stretches, generally for the reason that a map of such a line is available for filing, and certain legal rights result from such a filing. With a compass, no backsight need be taken, and, in passing small obstacles, a compass will save time on this account. A transit line can be carried past an obstacle readily by a zigzag line. Common practice among engineers favors the use of the transit rather than the compass. Stakes are set, at every "Station," 100 feet apart, and the stakes are marked on the face, the first 0, the next 1, then 2, and so to the end of the line. A stake set 1025 feet from the beginning would be marked 10 + 25.

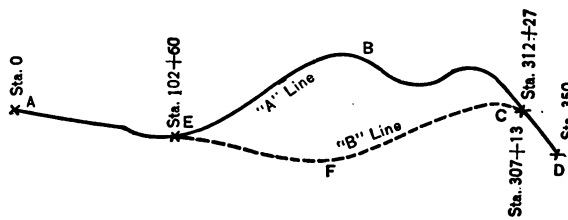
Levels are taken on the ground at the side of the stakes, and as much oftener as there is any change in the inclination of the ground. All the surface heights are platted on a profile, and the grade line adjusted.

16. The line should be run from a governing point towards country allowing a choice of location, that is from a pass or from an important bridge crossing, towards country offering no great difficulties. There is an advantage in running from a summit downhill, subject, however, to the above considerations. In running from a summit down at a prescribed rate of grade, an experienced engineer will carry the line so that, at the end of a day's work, the levels will show the line to be about where it ought to be. For this purpose, the levels must be worked up and the profile platted to date at the close of each day. Any slight change of line found necessary can then be made early the next morning. A method sometimes adopted in working down from a summit is for the locating engineer to

plat his grade line on the profile, daily in advance, and then during the day, plat a point on his profile whenever he can conveniently get one from his leveler, and thus find whether his line is too high or too low.

17. Occasionally the result of two or three days' work will yield a line extremely unsatisfactory, enough so that the work of these two or three days will be abandoned. The party "backs up" and takes a fresh start from some convenient point. In such case the custom is not to tear out several pages of note-book, but instead to simply draw a line across the page and mark the page "Abandoned." At some future time the abandoned notes may convey useful information to the effect that this line was attempted and found unavailable. In general, all notes worth taking are worth saving.

Sometimes after a line has been run through a section of country, there is later found a shorter or better line.



In the figure used for illustration, the first line, "A" Line, is represented by AEBCD, upon which the stations are marked continuously from A to D, 350 stations. The new line, "B" Line, starts from E, Sta. 102 + 60, and the stationing is held continuous from O to where it connects with the "A" Line at C. The point C is Sta. 312 + 27 of the "A" Line, and is also Sta. 307 + 13 of the "B" Line. It is not customary to restake the line from C to D in accordance with "B" Line stationing. Instead of this, a note is made in the note-books as follows: —

Sta. 312 + 27 "A" Line = 307 + 13 "B" Line.

Some engineers make the note in the following form: —

Sta. 307 to 313 = 86 ft.

The first form is preferable, being more direct and less liable to cause confusion.

18. All notes should be kept clearly and nicely in a note-book — never on small pieces of paper. The date and the names of members of the party should be entered each day in the upper left-hand corner of the page. An office copy should be made as soon as opportunity offers, both for safety and convenience. *The original notes should always be preserved;* they would be admissible as evidence in a court of law where a copy would be rejected. When two or more separate or alternate lines are run, they may be designated

Line "A," Line "B," Line "C,"

or "A" Line, "B" Line, "C" Line.

19. The Organization of Party may be as follows: —

1.	Locating Engineer.	
2.	Transitman.	Transit Party.
3.	Head Chainman.	
4.	Stakeman.	
5.	Rear Chainman.	
6.	Back Flag.	
7.	Axemen (one or more).	
8.	Leveler.	Level Party.
9.	Rodman (sometimes two).	
10.	Topographer.	Topographical Party
11.	Assistant.	
12.	Cook.	
13.	Teamster.	

20. The Locating Engineer is the chief of party, and is responsible for the business management of the camp and party, as well as for the conduct of the survey. He determines where the line shall run, keeping ahead of the transit, and establishing points as foresights or turning-points for the transitman. In open country, the extra axeman can assist by holding the flag at turning-points, and thus allowing the locating engineer to push on and pick out other points in advance. The locating engineer keeps a special note-book or memorandum book; in it he notes on the ground the quality of material, rock, earth, or whatever it may be; takes notes to determine the lengths and positions of bridges, culverts, and other structures; shows the localities of timber, building stones, borrow pits, and

other materials valuable for the execution of the work; in fact, makes notes of all matters not properly attended to by the transit, leveling, or topography party. The rapid and faithful prosecution of the work depend upon the locating engineer, and the party ought to derive inspiration from the energy and vigor of their chief, who should be the leader in the work. In open and easy country, the locating engineer may instill life into the party by himself taking the place of the head chainman occasionally. In country of some difficulty, his time will be far better employed in prospecting for the best line.

21. The Transitman does the transit work, ranges in the line from the instrument, measures the angles, and keeps the notes of the transit survey. The following is a good form for the left-hand page of the note-book: —

Station	Point	Deflection	Observed Bearing	Calculated Bearing
7				
6	⊙ + 24	33° 02′ R	N 3° 30′ E	N 3° 38′ E
5			N 29° 30′ W	N 29° 24′ W
4	⊙	12° 09′ L		
3				
2				
1			N 17° 15′ W	N 17° 15′ W
0	⊙			

Notes of topography and remarks are entered on the right-hand page, which, for convenience, is divided into small squares by blue lines, with a red line running up and down through the middle.

The stations run from bottom to top of page. The bearing is taken at each setting and recorded *just above* the corresponding point in the note-book, or opposite a part of the line, rather than opposite the point. Ordinarily, the transitman takes the bearings of all fences and roads crossed by the line, finds the stations from the rear chainman, and records them in their proper place and direction on the right-hand page of the note-book. Section lines of the United States Land Surveys should be

observed in the same way. The transitman is next in authority to the locating engineer, and directs the work when the latter is not immediately present. The transitman, while moving from point to point, setting up, and ranging line, limits the speed of the entire party, and should waste no time.

22. The Head Chainman carries a "flag" and the forward end of the tape, which should be held level and firm with one hand, while the flag is moved into line with the other. He should always put himself nearly in line before receiving a signal from the transitman; plumbing may be done with the flag. When the point is found, the stakeman will set the stake. When a suitable place for a turning-point is reached, a signal should be given the transitman to that effect. A nail should be set in top of a "plug" at all turning-points. A proper understanding should be had with the transitman as to signals.

Signals from the Transitman.

A horizontal movement of the hand indicates that the rod should be moved as directed.

A swinging movement of the hand, "Plumb the rod as indicated."

A movement of both hands, or waving the handkerchief freely above the head, means "All right."

At long distances, a handkerchief can be seen to advantage; when snow is on the ground, something black is better.

Signals from the Head Chainman.

Setting the bottom of flag on the ground and waving the top, means "Give the line."

Raising the flag above the head and holding it horizontal with both hands: "Give line for a turning-point."

The "all right" signal is the same as from the transitman.

In all measurements less than 100 feet (or a full tape), the head chainman holds the end of the tape, leaving the reading of the measurement to the rear chainman.

The head chainman regulates the speed of the party during the time that the instrument is in place, and should keep alive all the time. The rear chainman will keep up as a matter of necessity.

23. The Stakeman carries, marks, and drives the stakes at the points indicated by the head chainman. The stakes should

Levels should also be taken of high-water marks wherever traces of these are visible. The rodman carries a small note-book in which he enters the rod readings at all turning-points. In country which is open, but not level, the transit party is liable to outrun the level party. In such cases greater speed will be secured by the use of two rodmen.

29. The Topographer is, or should be, one of the most valuable members of the party. In times past it has not always been found necessary to have a topographer, or if employed, his duty has been to sketch in the general features necessary to make an attractive map, and represent hills and buildings sufficiently well with reference to the line to show, in a general way, the reason for the location adopted. Sometimes the chief of the party has for this purpose taken the topography. At present the best practice favors the taking of accurate data by the topography party.

The topographer (with one or two assistants) should take the station and bearing (or angle) of every fence or street line crossed by the survey (unless taken by the transit party); also take measurements and bearings for platting all fences and buildings near enough to influence the position of the Location; also sketch, as well as may be, fences, buildings, and other topographical features of interest which are too remote to require exact location; and finally establish the position of contour lines, streams, and ponds, within limits such that the Location may be properly determined in the contoured map.

The work of locating contours is usually accomplished by the use of hand level and tape (distances carefully paced may, in many cases, be sufficiently accurate). The level party has determined the elevations of the ground at each "station" set by the transit party. These elevations are given the topographers to serve as bench marks for use in locating contours. It is customary to fix on the ground the points where the contours cross the center line, where they cross lines at right angles to the center line at each station, and occasionally additional points; then to sketch the contours by eye between these points. Cross section sheets in blocks or in book form are used for this purpose. The usual contour interval is 5 feet.

A point on a contour is found as follows. The topographer stands at the station stake; a measurement is taken, by tape

or rod, of the distance from the topographer's feet to his eye; this added to the surface height at center stake (as obtained from the level party) gives the "height of eye" above datum. The difference between this "height of eye" and the elevation of the contour gives the proper rod reading for fixing a point on the contour, and the rod is carried vertically along the ground until this reading is obtained. The point thus found is then located. The topographer uses this point, already fixed, as a turning point, finds anew his "height of eye," and proceeds to find a point on the next contour. It is more convenient at times to carry on the process in reverse order; that is, to hold the rod on the ground at the station, and let the topographer place himself where his feet are on the contour. The "height of eye" must be the distance from topographer's feet to eye added to the elevation of contour. The rod reading at the station will be the difference between this "height of eye" and the elevation of the ground at the station.

The hand level is somewhat lacking in precision, but by making a fresh start at each station as a bench mark, cumulative errors are avoided, and fair results secured by careful work. Instead of a hand level, some topographers use a clinometer, and take and record side slopes as a basis for contour lines.

Topography can be taken rapidly and well by stadia survey or by plane table. This is seldom done, as many engineers are not sufficiently familiar with their use. Much more accurate results may be reached by plane table, and a party of three, well skilled in plane table work, will accomplish more than a party of three with hand level.

30. Some engineers advocate making a general topographical survey of the route by stadia, instead of the survey above described. In this case no staking out by "stations" would be done. All points occupied by the transit should be marked by plugs properly referenced, which can be used to aid in marking the Location on the ground after it is determined on the contour map. This method has been used a number of times, and is claimed to give economical and satisfactory results; it is probable that it will have constantly increasing use in the future, and may prove the best method in a large share of cases.

CHAPTER III.

III. LOCATION SURVEY.

31. The Location Survey is the final fitting of the line to the ground. In Location, curves are used to connect the straight lines or "tangents," and the alignment is laid out complete, ready for construction.

The party is much the same as in the preliminary, and the duties substantially the same. More work devolves upon the transitman on account of the curves, and it is good practice to add a "note-keeper" to the party; he takes some of the transitman's work, and greater speed for the entire party is secured. More skill is useful in the head chainman in putting himself in position on curves. He can readily range himself on tangent. The form of notes will be shown later. The profile is the same, except that it shows, for alignment notes, the *P. C.* and *P. T.* of curves, and also the degree and central angle, and whether to the right or left.

It is well to connect frequently location stakes with preliminary stakes, when convenient, as a check on the work.

In making the location survey, two distinct methods are in use among engineers: —

32. First Method of Location. — Use preliminary survey and preliminary profile as guides in reading the country, and locate the line upon the ground. Experience will enable an engineer to get very satisfactory results in this way, in nearly all cases. The best engineers, in locating in this way, as a rule lay the tangents first, and connect the curves afterwards.

33. Second Method. — Use preliminary line, preliminary profile, and especially the contour lines on the preliminary map; make a paper location, and run this in on the ground. Some go so far as to give their locating engineer a complete set of notes to run by. This is going too far. It is sufficient to fix,

on the map, the location of tangents, and specify the degree of curve. The second method is much more desirable, but the first method has still some use. It is well accepted, among engineers, that no reversed curve should be used; 200 feet of tangent, at least, should intervene. Neither should any curve be very short, say less than 300 feet in length.

34. A most difficult matter is the laying of a long tangent, so that it shall be straight. Lack of perfect adjustment and construction of instrument will cause a "swing" in the tangent. The best way is to run for a distant foresight. Another way is to have the transit as well adjusted as possible, and even then change ends every time in reversing, so that errors shall not accumulate. It will be noticed that the preliminary is run in without curves because more economical in time; sometimes curves are run however, either because the line can be run closer to its proper position, or sometimes in order to allow of filing plans with the United States or separate States.

35. In Location, a single tangent often takes the place of a broken line in the preliminary, and it becomes important to determine the direction of the tangent with reference to some part of the broken line. This is readily done by finding the coördinates of any given point with reference to that part of the broken line assumed temporarily as a meridian. The course of each line is calculated, and the coördinates of any point thus found. It simplifies the calculation to use some part of the preliminary as an assumed meridian, rather than to use the actual bearings of the lines. The coördinates of two points on the proposed tangent allow the direction of the tangent to be determined with reference to any part of the preliminary. When the angles are small, an approximation sufficiently close will be secured, by assuming in all cases that the cosine of the angle is 1.000000 and that the sines are directly proportional to the angles themselves. In addition to this, take the distances at the nearest even foot, and the calculation becomes much simplified.

36. The located line, or "Location," as it is often called, is staked out ordinarily by center stakes which mark a succession of straight lines, connected by curves to which the straight lines are tangent. The straight lines are by general usage called "**Tangents.**"

CHAPTER IV.

SIMPLE CURVES.

37. The curves most generally in use are circular curves, although parabolic and other curves are sometimes used. Circular curves may be classed as **Simple, Compound, Reversed,** or **Spiral.**

A Simple Curve is a circular arc, extending from one tangent to the next. The point where the curve leaves the first tangent is called the "*P. C.*," meaning the point of curvature, and the point where the curve joins the second tangent is called the "*P. T.*," meaning the point of tangency. The *P. C.* and *P. T.* are often called the Tangent Points. If the tangents be produced, they will meet in a point of intersection called the "**Vertex,**" *V.* The distance from the vertex to the *P. C.* or *P. T.* is called the "**Tangent Distance,**" *T.* The distance from the vertex to the curve (measured towards the center) is called the **External Distance,** *E.* The line joining the middle of the **Chord,** *C,* with the middle of the curve subtended by this chord, is called the **Middle Ordinate,** *M.* The radius of the curve is called the **Radius,** *R.* The angle of deflection between the tangents is called the **Intersection Angle,** *I.* The angle at the center subtended by a chord of 100 feet is called the **Degree of Curve,** *D.* A chord of less than 100 feet is called a **sub-chord,** *c*; its central angle a **sub-angle,** *d.*

38. The measurements on a curve are made:

(*a*) from *P. C.* by a sub-chord (sometimes a full chord of 100 ft.) to the next full station, then

(*b*) by chords of 100 feet each between full stations, and finally,

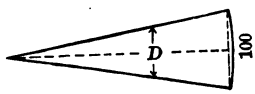
(*c*) from the last station on the curve, by a sub-chord (sometimes a full chord of 100 ft.) to *P. T.* The total distance from *P. C.* to *P. T. measured in this way,* is the **Length of Curve,** *L.*

39. The **Degree of Curve** is defined as the angle subtended by a *chord* of 100 feet, rather than by an *arc* of 100 feet.

Either assumption requires approximate methods either in calculations or measurements, if the convenient and customary methods are followed. On the merits of the question, it is best to accept the definition given, and the practice in this country is largely in harmony with this definition, which is adopted by the American Railway Engineering Association.

Outside of the United States a curve is generally designated by its Radius, R. In the United States for railroad purposes, a curve is generally designated by its Degree, D.

40. Problem. *Given* R.
Required D.



$$R \sin \tfrac{1}{2} D = \frac{100}{2}$$

$$\sin \tfrac{1}{2} D = \frac{50}{R} \qquad (1)$$

41. Problem. *Given* D.
Required R.

$$R = \frac{50}{\sin \tfrac{1}{2} D} \qquad (2)$$

Example. *Given* $D = 1°$.

$$R_1 = \frac{50}{\sin \tfrac{1}{2} D} \qquad \begin{array}{lll} 50 & \log & 1.698970 \\ 0°\,30' & \log \sin & \underline{7.940842} \\ & \log & 3.758128 \end{array}$$

$$R_1 = 5729.6$$

42. Problem. *Given* R_1 (radius of 1° curve) or D_1.
Required R_a (radius of any given curve of degree $= D_a$).

$$R_1 = \frac{50}{\sin \tfrac{1}{2} D_1} \qquad R_a = \frac{50}{\sin \tfrac{1}{2} D_a}$$

$$\frac{R_a}{R_1} = \frac{\sin \tfrac{1}{2} D_1}{\sin \tfrac{1}{2} D_a} \qquad R_a = R_1 \frac{\sin \tfrac{1}{2} D_1}{\sin \tfrac{1}{2} D_a} \qquad (3)$$

In the case of small angles, the angles are proportional to the sines (approximately),

$$R_a = R_1 \frac{\tfrac{1}{2} D_1}{\tfrac{1}{2} D_a}; \quad R_a = R_1 \frac{D_1}{D_a} \qquad (3A)$$

But $R_1 = 5730$ to nearest foot,

$$R_a = \frac{5730}{D_a} \text{ (approx.)} \qquad (4)$$

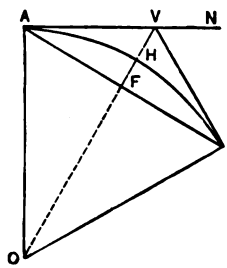
Example. $R_{10} = 573.7$ by (3), or by Allen's Table I.
$= 573.0$ by (4) (approx.)

Some engineers use shorter chords for sharp curves, as 1° to 7°, 100 ft.; 8° to 15°, 50 ft.; 16° to 20°, 25 ft.

Values of R and D are readily convertible. For this purpose, use Table I., Allen [rather than formula (1) or (2)], when accurate results are required. In problems later, where either R or D is given, both will, in general, be assumed to be given. Approximate values can be found without tables by (4). The radius of a 1° curve = 5730 should be remembered. Precise results are, in general, necessary.

43. Problem. *Given I, also R or D.*

Required T.



$$\text{AOB} = \text{NVB} = I$$

$$\text{AO} = \text{OB} = R$$

$$\text{AV} = \text{VB} = T$$

$$T = R \tan \tfrac{1}{2} I \qquad (5)$$

Example. *Given* $D = 9$; $I = 60° 48'$.

Required T_9.

Table I., $R_9 \log = 2.804327$

$30° 24' \log \tan = 9.768414$

$T_9 = 373.9 \log \overline{2.572741}$

Note that $\log R_9$ is taken directly from Table I.

44. Approximate Method.

$$T_1 = R_1 \tan \tfrac{1}{2} I; \quad T_a = R_a \tan \tfrac{1}{2} I$$

$$\frac{T_a}{T_1} = \frac{R_a}{R_1} = \frac{D_1}{D_a} = \frac{1}{D_a} \text{ (approx.)}$$

$$T_a = \frac{T_1}{D_a} \text{ (approx.)} \qquad (6)$$

Table III., Allen, gives values of T_1 for various values of I.

Table IV., Allen, gives a correction to be added *after* dividing by D_a.

Example. As before. *Given* $D = 9$; $I = 60° 48'$.

Required T_9.

Table III., T_1 $60° 48' = 3361.6(9$

$T_9 = 373.51$ (approx.)

Table IV., correction, 9° and 61° $= .38$

$T_9 = 373.9$ (exact)

the same as before

45. Problem. *Given I, also R or D.*

Required E.

Using previous figure, $VH = E = R \operatorname{exsec} \frac{1}{2} I$ (7)

Table XXXIII. shows definition of exsecant.
Table XIX. gives natural exsec.
Table XV. gives logarithmic exsec.
Approximate Method.

By method used for (6), $E_a = \frac{E_1}{D_a}$ (approx.) (8)

Table V. gives values for E_1.

46. Problem. *Given I, also R or D.*

Required M.

$$FH = M = R \operatorname{vers} \tfrac{1}{2} I \qquad (9)$$

Table XXXIII. shows definition of versine.

Table XIX. gives natural vers.
Table XV. gives logarithmic vers.
Table II. gives certain middle ordinates.

47. Problem. *Given I, also R or D.*

Required chord AB $= C$.

$$C = 2 R \sin \tfrac{1}{2} I \qquad (10)$$

Table VIII. gives values for certain long chords.

48. Transposing, we find additional formulas, as follows:

from (5) $$R = T \cot \tfrac{1}{2} I \tag{11}$$

(7) $$R = \frac{E}{\text{exsec } \frac{1}{2} I} \tag{12}$$

(9) $$R = \frac{M}{\text{vers } \frac{1}{2} I} \tag{13}$$

(10) $$R = \frac{C}{2 \sin \frac{1}{2} I} \tag{14}$$

(4) $$D_a = \frac{5730}{R_a} \text{(approx.)} \tag{15}$$

(6) $$D_a = \frac{T_1}{T_a} \text{(approx.)} \tag{16}$$

(8) $$D_a = \frac{E_1}{E_a} \text{(approx.)} \tag{17}$$

49. Problem. *Given sub-angle d, also R or D.*
Required sub-chord c.

$$c = 2 R \sin \tfrac{1}{2} d \tag{18}$$

Approximate Method.

$$100 = 2 R \sin \tfrac{1}{2} D$$

$$\frac{c}{100} = \frac{\sin \frac{1}{2} d}{\sin \frac{1}{2} D} = \frac{d}{D} \text{(approx.)} \tag{19}$$

The precise formula is seldom if ever used.

50. Problem. *Given sub-chord c, also R or D.*
Required sub-angle d.

$$d = \frac{cD}{100} \tag{20}$$

The value $\frac{d}{2}$ is more frequently needed and

$$\frac{d}{2} = \frac{c}{100} \frac{D}{2} \tag{21}$$

A modification of this formula is as follows:

$$\frac{d}{2} = \frac{cD}{200}$$

for $D = 1$

$$\frac{d}{2} = c\frac{60'}{200} = c \times 0.3'$$

for any value D_a

$$\frac{d}{2} = c \times 0.3' \times D_a \text{ (result in minutes)} \qquad (22)$$

This gives a very simple and rapid method of finding the value of $\frac{d}{2}$ in minutes, and the formula should be remembered.

Example. *Given sub-chord* = 63.7. $D = 6° 30'$.

Required sub-angle d $\left(or\ \frac{d}{2}\right)$.

I. By (20)

63.7

6.5 = D

3185

3822

414.05

4°.14

60′

$d = 4° 08'$

$\frac{d}{2} = 2° 04'$

II. By (21)

63.7

$\frac{3.25}{3185} = \frac{D}{2}$

1274

1911

207.025

2°.07

60′

$\frac{d}{2} = 2° 04'$

III. By (22)

63.7

0.3

19.11

6.5 = D

9555

11466

124.215 minutes

$\frac{d}{2} = 2° 04'$

Method III. is often preferable to I. or II.

51. Problem. *Given I and D.*
Required L.

The "Length of Curve" L is the distance around the curve, measured as stated in § 38, or $L = c_1 + 100\,n + c_2$.

(*a*) When the *P.C.* is at a *full station*, D will be contained in I a certain number of times n, and there will remain a sub-angle d_2 subtended by its chord c_2, and $L = 100\,n + c_2$.

$$\frac{I}{D} = n + \frac{d_2}{D} = \quad n + \frac{c_2}{100} \text{ (approx.)}$$

$$100\,\frac{I}{D} \qquad = 100\,n + c_2 = L \text{ (approx.)}$$

(*b*) When the *P.C.* is at a *sub-station* and *P.T.* at a *full station*, the same reasoning holds, and

$$L = 100\,\frac{I}{D} \text{ (approx.)}$$

(*c*) When both *P.C.* and *P.T.* are at *sub-stations*, the same formula holds

$$L = 100\,\frac{I}{D} \text{ (approx.)} \qquad (23)$$

Transposing,
$$I = \frac{LD}{100} \text{ (approx.)} \qquad (24)$$

$$D = \frac{100\,I}{L} \qquad (25)$$

These formulas (23)(24)(25), though approximate, are the formulas in common use.

Example. *Given* 7° *curve.* $I = 39°\ 37'$. *Required L.*

$I = \ 39°\ 37$
$D = 7)\overline{39.6167°}$
$\quad 5.6595 +$ $\qquad L = 566.0$

Example. *Given D and L. Required I.*
Given 8° *curve.*
also, $P.T. = 93 + 70.1$
$P.C. = \underline{86 + 49.3}$
$L = \ 7 \quad 20.8$
$D = \qquad\quad 8$
$\qquad 57.664$
$\qquad\quad 60'$
$\qquad 39.84 \qquad I = 57°\ 40'$

52. Field-work of finding *P. C.* and *P. T.*

In running in the line, it is common practice to continue the stationing as far as V, to set a plug and mark a witness stake with the station of V as thus obtained. The angle I is then measured and "repeated" as a "check."

Having given I only, an infinite number of curves could be used. It is, therefore, necessary to assume additional data to determine what curve to use. It is common to proceed as follows:

(a) Assume either (1) D directly.

(2) E and calculate D.

(3) T and calculate D.

It is often difficult to determine off-hand what degree of curve will best fit the ground. Frequently the value of E_a can be readily determined on the ground. The determination of D from E_a is readily made, using the approximate formula $D_a = \frac{E_1}{E_a}$. Similarly, we may be limited to a given (or ascertainable) value of T_a, and from this readily find $D_a = \frac{T_1}{T_a}$.

This process is to determine what value of D_a will fit the ground, and it is convenient, generally, to use the degree or half degree nearest to that calculated. (Some engineers use 1° 40′ = 100′ and 3° 20′ = 200′, etc., rather than 1° 30′ or 3° 30′, etc.)

When the D_a is thus determined, all computations must be strictly based on this value of D_a.

(b) From the data finally adopted T is *calculated anew.*

(c) The instrument still being at V, the $P. T.$ is set by laying off T. It is economical to set $P. T.$ before $P. C.$

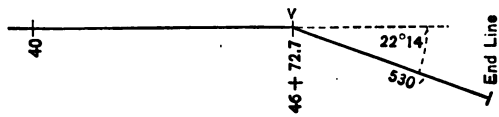
(d) The station of $P. C.$ is calculated and $P. C.$ set from the nearest station stake (or by measuring back from V).

(e) The length of curve L is calculated, and station of $P. T.$ thus determined (not by adding T to station of V).

Whether D, E, or T shall be assumed depends upon the special requirements in each case. Curves are often run out from $P. C.$ without finding or using V, but the best engineering usage seems to be in favor of setting V, whenever this is at all practicable, and from this finding the $P. C.$ and $P. T.$

53. Example. *Given a line, as shown in sketch.*
Required a Simple Curve to connect the Tangents.

P. T. is to be at least 300 ft. from end of line.
Use smallest degree or half degree consistent with this.
Find degree of curve and stations of *P. C.* and *P. T.*



530
300

Table III. $22° 14'$ $T_1 = 1125.8 \left(\frac{230}{4.9} \right. = T$ (approx.)
92 use 5° curve
205

$T_1 = 1125.8(5°$
225.16

$V = 46 + 72.7$

Table IV. corr. .07 $I = 22° 14'$ $T = 2 + 25.2$
$T = 225.2$ $= 22°.2333(5°$ $P.C. = 44 + 47.5$
$L = 444.7$ $L = 4 + 44.7$
$P.T. = 48 + 92.2$

It will be noticed that the station of the *P. T.* is found by adding *L* to the stations of the *P. C.* (*not* by adding *T* to the station of *V*).

Similarly *Given* $E = 17$ ft.
Table V. $22° 14'$ $E_1 = 109.6 \left(\frac{17}{6.4} \right. = E$
102 use 6° 30′ curve
76

$T_1 = 1125.8(6.5$
173.20

$I = 22°.2333(6.5$ $V = 46 + 72.7$
corr. .09 $L = 342.1$ $T = 1 + 73.3$
$T = 173.3$ $P.C. = 44 + 99.4$
$L = 3 + 42.1$
$P.T. = 48 + 41.5$

Under the conditions prescribed above, when *T* is given, the degree, or half degree, next larger must be used, in order to secure *at least* the required distance (to end of line above).

When *E* is given, the nearest half degree is generally used.

54. Method of **Deflection Angles.**

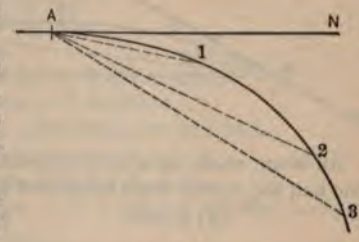
If at any point on an existing curve a tangent to the curve be taken, the angles from the tangent to any given points on the curve may be measured, and the angles thus found may be called **Total Deflections** to those points (as NA1, NA2, NA3).

In laying out successive points upon a straight line (as on a "Tangent"), each point is generally fixed by

(*a*) measurement from the preceding point and

(*b*) line;

the line on a tangent will be the same for all points.



Similarly, in laying out a curve, successive points may be fixed by

(*a*) measurement from the preceding point and

(*b*) line;

the line in this case, for the curve, will be that found by using the *total deflection* calculated for each point. In the figure preceding, the chord distance A1 and the total deflection NA1 fix point 1; the chord distance 1–2 and total deflection NA2 fix point 2; and 2–3 and NA3 fix 3. A curve can be conveniently laid out by this method if the proper total deflections can be readily computed.

55. The method of "Deflection Angles" is well adapted to surveying an existing curve; it is also well adapted to laying out any curve, provided only that it is possible to readily determine

(*a*) the "Total Deflection Angles" and

(*b*) the chord lengths that go with them.

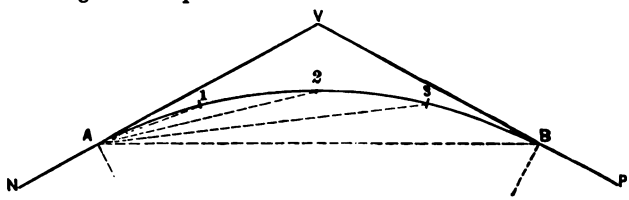
In the case of "*Simple Curves*," the "total deflections" can be readily computed, and the method of "deflection angles" is therefore well adapted to laying them out.

In the case of "spiral" or "transition" curves, tables have commonly been computed, so that the angles and chords are taken from the tables. Any curve which has been surveyed by this method can be restaked on the ground by using the deflection angles and chords measured and recorded.

56. Problem. To find the *Total Deflections* for a Simple Curve having *given* the *Degree.*

I. *When the curve begins and ends at even stations.*

The distance from station to station is 100 feet. The deflection angles are required.



An acute angle between a tangent and a chord is equal to one half the central angle subtended by that chord

$$A\,1 = 100 \qquad V\,A\,1 = \tfrac{1}{2}D$$

The acute angle between two chords having their vertices in the circumference is equal to one half the arc included between those chords.

$$1 - 2 = 100 \text{ and } 1\,A\,2 = \tfrac{1}{2}D \quad \text{Similarly,}$$
$$2 - 3 = 100 \text{ and } 2\,A\,3 = \tfrac{1}{2}D$$
$$3 - B = 100 \text{ and } 3\,A\,B = \tfrac{1}{2}D$$

This angle $\frac{1}{2}D$ is called by Henck and Searles the **Deflection Angle**, and will be so called here. Shunk and Trautwine call it the "*Tangential Angle.*" The weight of engineering opinion appears to be largely in favor of the "Deflection Angle."

The "*Total Deflections*" will be as follows:

$$V\,A\,1 = \tfrac{1}{2}D$$
$$V\,A\,2 = V\,A\,1 + \tfrac{1}{2}D$$
$$V\,A\,3 = V\,A\,2 + \tfrac{1}{2}D$$

VAB will be found by successive increments of $\frac{1}{2}D$.

$VAB = VBA = \frac{1}{2}I$. This furnishes a "check" on the computation.

II *When the curve begins and ends with a sub-chord.*

$$V\,A\,1 = \tfrac{1}{2}d$$
$$V\,A\,2 = V\,A\,1 + \tfrac{1}{2}D$$
$$V\,A\,3 = V\,A\,2 + \tfrac{1}{2}D$$

VAB is found by adding $\frac{1}{2}\,d_2$ to previous "total deflection."

VAB = VBA = $\frac{1}{2}\,I$. This furnishes "check." The total deflections should be calculated by successive increments; the final "check" upon $\frac{1}{2}\,I$ then checks all the intermediate total deflections. The example on next page will illustrate this.

57. Field-work of laying out a simple curve having given the position and station of *P.C.* and *P.T.*

(*a*) Set the transit at *P.C.* (A).

(*b*) Set the vernier at 0.

(*c*) Set cross hairs on V (or on N and reverse).

(*d*) Set off $\frac{1}{2}\,d_1$ (sometimes $\frac{1}{2}\,D$) for point 1.

(*e*) Measure distance c_1 (sometimes 100) and fix 1.

(*f*) Set off total deflection for point 2.

(*g*) Measure distance 1–2 = 100 and fix 2, etc.

(*h*) When total deflection to B is figured, see that it = $\frac{1}{2}\,I$, thus "checking" calculations.

(*i*) See that the proper calculated distance c_2 and the total deflection to B agree with the actual measurements on the ground, checking the field-work.

(*k*) Move transit to *P.T.* (B).

(*l*) Turn vernier back to 0, and *beyond* 0 *to* $\frac{1}{2}\,I$.

(*m*) Sight on A.

(*n*) Turn vernier to 0.

(*o*) Sight towards V (or reverse and sight towards P), and see that the line checks on V or P.

It should be observed that three "checks" on the work are obtained.

1. The calculation of the total deflections is checked if total deflection to B = $\frac{1}{2}\,I$.

2. The chaining is checked if the final sub-chord measured on the ground = calculated distance.

3. The transit work is checked if the total deflection to B brings the line accurately on B.

The check in 1 is effective only when the total deflection for each point is found by adding the proper angle to that for the preceding point.

The check in 3 assures the general accuracy of the transit work, but does not prevent an error in laying off the total deflection at an intermediate point on the curve.

58. Example. *Given Notes of Curve*

P. T. 13 + 45.0
P. C. 10 + 74.0 — 6° curve **L**

Required the "total deflections"

to sta. 11 $c_1 = 26$, $.3$, 7.8, $6°$

$\frac{d_1}{2} = 46.8 = 0° 47'$ to 11

$3°$

$3° 47'$ to 12

$c_2 = 45$, $.3$, 13.5, $6°$

$3°$

$6° 47'$ to 13

$\frac{d_2}{2} = 81.0 = 1° 21'$

$8° 08'$ to 13 + 45

13 + 45.0
10 + 74.0
2 71.0 = L
6°
16.26
60′
15.6′

16°

16′

16° 16′ = I

8° 08′ = $\frac{1}{2} I$ "check"

59. Caution.

If a curve of nearly 180° = I is to be laid out from A, it is evident that it would be difficult or impossible to set the last point accurately, as the "intersection" would be bad. It is undesirable to use a total deflection greater than 30°.

It may be impossible to see the entire curve from the *P.C.* at A.

It will, therefore, frequently happen that from one cause or another the entire curve cannot be laid out from the *P.C.*, and it will be necessary to use a modification of the method described above.

60. Field-work. *When the entire curve cannot be laid out from the P. C.*

First Method.

(*a*) Lay out curve as far as C, as before.

(*b*) Set transit point at some convenient point, as C (even station preferably) and move transit to C.

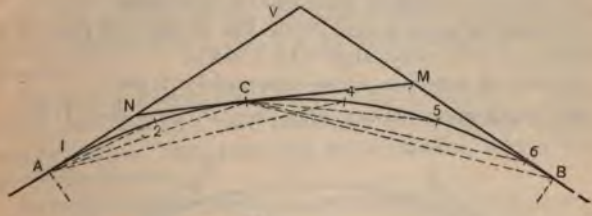
(*c*) Turn vernier back to 0°, *and beyond* 0° by the value of angle VAC.

(*d*) Sight on A.

(*e*) Turn vernier to 0°. See that transit line is on auxiliary tangent NCM (VAC = NCA being measured by $\frac{1}{2}$ arc AC).

(*f*) Set off new deflection angle ($\frac{1}{2}d$ or $\frac{1}{2}D$).

(*g*) Set point 4, and proceed as in ordinary cases.



Second Method.

(*a*) Set point C as before, and move transit to C.

(*b*) Set vernier at 0° and sight on A.

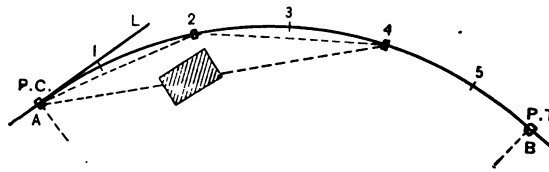
(*c*) Set off the proper "total deflection" for the point 4 = VA 4 NCA + MC 4 = VA 4, each measured by $\frac{1}{2}$ arc AC 4.

(*d*) Reverse transit and set point 4.

(*e*) Set off and use the proper "total deflections" for the remaining points.

The second method is in some respects more simple, as the notes and calculations, and also setting off angles, are the same as if no additional setting were made. By the first method the deflection angles to be laid off will, in general, be even minutes, often degrees or half degrees, and are thus easier to lay off. It is a matter of personal choice which of the two methods shall be used. It will be disastrous to attempt an incorrect combination of parts of the two methods.

61. Field-work. *When the transit is in the curve, and the P.C. is not visible.*



(*a*) Compute deflection angles, *P.C.* to *P.T.*; check on $\frac{I}{2}$ (same as in § 56).

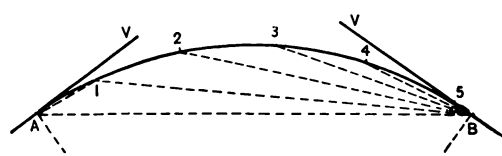
(*b*) Set vernier at deflection angle computed for point (*e.g.* 2) used as backsight.

(*c*) Set line of sight on backsight (2) and clamp.

If vernier be made to read 0°, the line of sight will then be in direction of *P.C.* (since angle L A 2 = 2 4 A).

(*d*) Set off deflection angles computed for 5, etc.

62. Field-work. *When entire curve is visible from P.T.*



(*a*) Compute deflection angles, *P.C.* to *P.T.*; check on $\frac{I}{2}$ (same as in § 56).

(*b*) Set transit at *P.T.* with vernier at 0° and sight on *P.C.*

(*c*) Set off computed angles for 1, 2, 3, 4, 5.

(*d*) Set off $\frac{I}{2}$ and sight at V for check on transit work.

This method is preferable to that given in § 57. It saves the transit setting at *P.C.* The long sights are taken first, before errors of chaining have accumulated and before the transit has settled or warped in the sunlight. The last point on curve is set at a small angle with the tangent, so that the intersection is good and any accumulated errors of chaining will not much affect the line. The method is already accepted practice.

63. Metric Curves.

In Railroad Location under the "**Metric System**" a chain of 100 meters is too long, and a chain of 10 meters is too short. Some engineers have used the 30-meter chain, some the 25-meter chain, but lately the 20-meter chain has been generally adopted as the most satisfactory. Under this system a "*Station*" is 10 meters. Ordinarily, every second station only is set, and these are marked Sta. 0, Sta. 2, Sta. 4, etc. On curves, *chords of 20 meters* are used. Usage among engineers varies as to what is meant by the *Degree of Curve* under the metric system. There are two distinct systems used, as shown below.

I. The *Degree of Curve* is the *angle at the center* subtended by a chord of 1 chain of *20 meters.*

II. The *Degree of Curve* is the *deflection angle* for a chord of 1 chain of *20 meters* (or one half the angle at the center).

II. Or, very closely, the *Degree of Curve* is the *angle at the center* subtended by a chord of *10 meters* (equal to 1 station length).

For several reasons the latter system is favored here. Tables upon this basis have been calculated, giving certain data for metric curves. Such tables are to be found in Allen's Field and Office Tables.

In many countries where the metric system is used, it is not customary to use the *Degree of Curve*, as indicated here. In Mexico, where the metric system is adopted as the only legal standard, very many of the railroads have been built by companies incorporated in this country, and under the direction of engineers trained here. The usage indicated above has been the result of these conditions. If the metric system shall in the future become the only legal system in the United States, as now seems possible, one of the systems outlined above will probably prevail.

In foreign countries where the *Degree of Curve* is not used, it is customary, as previously stated, to designate the curve by its radius R, and to use even figures, as a radius of 1000 feet, or 2000 feet, or 1000 meters, or 2000 meters. As the radius is seldom measured on the ground, the only convenience in even figures is in platting, while there is a constantly recurring inconvenience in laying off the angles.

64. Form of Transit Book (left-hand page).

(Date)
(Names of Party)

Station	Points	Descrip. of Curve	Total Deflect.	Observed Course
114				
113				
112				
111				
110				
109	⊙+ 90.0 *P. T.*		11° 15′	N 46° 00′ E
108			9° 00′	
107		$R = 1146.3$	6° 30′	
106	⊙+ 68.0 *V*	$L = 450.0$	4° 00′	
105		$T = 228.0$	1° 30′	
104	⊙+ 40.0 *P.C.*	$I = 22° 30′$ 5° Right		
103				
102				
101				
100				
99				N 23° 15′ E
98				

V is not a point on the curve. Nevertheless, it is customary to record the station found by chaining along the tangent.

The right-hand page is used for survey notes of crossings of fences and various similar data. It seems unnecessary to show a sample here.

65. Circular Arcs. For general railroad work, the Length of Curve is the distance measured by a series of chords as defined in § 38 and § 51. For certain purposes, largely outside of railroad work, the actual length of arc is required. Where the line of a street is curved, the length of the side line of street, the property line of a lot or estate, may be required. Furthermore, both in railroad and street railway work, actual lengths of rails are sometimes required.

Problem. *Given the Central Angle I and Radius R.*
Required the Length of Arc.

Table XX., p. 205, Allen, gives lengths of circular arcs for radius = 1. The values for degrees, minutes and seconds are added; the sum multiplied by R is the required length of arc.

Example. *Given* $I = 18° 43' 29''$; $R = 600$.
Required Length of Arc and Deflection Angles.

	18°	0.3141593
	43′	0.0125082
	29″	0.0001406
		0.3268081
	R	600
Length of Arc = 196.08		196.08486

Where a series of points are to be set on the circular arc, there are several methods available, each of which has some desirable features.

I. (*a*) *Divide the entire arc length into an equal number of parts.*

(*b*) Compute the deflection angles to correspond.

(*c*) Compute the chord lengths to correspond.

In the example above, if 4 intermediate points are to be set on the arc, the length of arc will be divided by 5; the final deflection angle will be $\frac{1}{2} I$; and the first deflection angle, i_1, will be $\frac{1}{2} I \div 5$.

$5)\overline{196.08} =$ Length of Arc
39.216

$I = 18° 43' 29''$
$\frac{1}{2} I = 9° 21' 44''$ (5
$i_1 = 1° 52' 21''$

The deflection angles will be (to nearest $\frac{1}{2}$ minute) 1° 52′ 30″; 3° 44′ 30″; 5° 37′; 7° 29′ 30″; 9° 21′ 30″. For chaining, the length of chord is necessary and may be computed by formula (10). Where the radius is large, natural sines may not give satisfactory results, and it may be necessary to use the auxiliary tables of log. sines.

A simpler method is to use Allen's Table XX., A, which gives for $R = 1$ the difference between arc and chord for various central angles.

For central angle 3° 45′ diff. = 0.000012 Table XX., A.

$$R = \frac{600}{0.007}$$

Arc = 39.216

Chord = 39.209

The *P. T.* of the circular arc should be set with the required precision by long chord from *P. C.* and the several chords measured with a degree of precision sufficient to secure a "check" against material error.

II. (*a*) *Use a series of equal chords of convenient length, followed by a sub-chord to the P. T.*

(*b*) Compute deflection angles to correspond.

(*c*) Compute chord lengths to correspond.

Example. *Given as before* $I = 18° 43′ 29″$; $R = 600$.

Take chord length of 40 ft.

Let i_1 = deflection angle for chord of 40 ft.

Then $\sin i_1 = \frac{20}{600}$.

$$i_1 = 1° 54′ 37″$$

and $d = 3° 49′ 14″$ = corresponding central angle.

For central angle 3° 49′ diff. = 0.000012 Table XX., A.

$$R = \frac{600}{0.007}$$

arc = 40.007

4 lengths of arc = 160.028

entire arc = 196.085 from p. 37

sub-arc = 36.057 for $R = 600$

36.057 ÷ 600 = 0.060095 = sub-arc for $R = 1$

From p. 38, 0.0600950 = sub-arc for $R = 1$

Table XX., 3° 0.0523599

0.0077351

26′ 0.0075631

0.0001720

35″ 0.0001697

For central angle 3° 27′ diff. = 0.000009

R = 600

0.005

sub-arc = 36.057

sub-chord = 36.052

III. (*a*) *Use uniform deflection angles to some convenient even minute, except for final sub-chord.*

(*b*) Compute chord lengths to correspond.

(*c*) Compute arc lengths to correspond.

Example. *Given as before.* $I = 18° 43′ 29″$ $R = 600$

For 5 equal arcs $i_1 = 1° 52′ 21″$

Assume $i_1 = 2° 00′$; then $2\,i_1 = 4° 00′$ = central angle.

For central angle 4° diff. = 0.000014 Table XX., A.

R = 600

0.008

Chord length for 4° = 2 × 600 × sin 2° = 41.880

arc length = 41.888

$I = 18° 43′ 29″$

4 × central angle 4° = 16°

final sub-angle d_2 = 2° 43′ 29″

For central angle 2° 43′ diff. = 0.000004 Table XX., A.

R = 600

0.002

For central angle 2° 43′ 29″ arc = 0.0475554 Table XX.

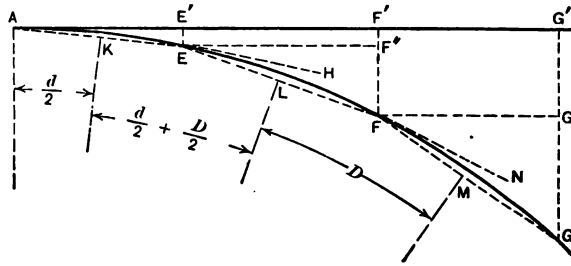
R = 600

28.53324

diff. = 0.002

final sub-chord = 28.531

66. Problem. *Given* D and stations of $P.C.$ and $P.T.$
Required to lay out the curve by the method of **Offsets from the Tangent.**



Let AG′ be tangent to curve AG

Find $E'AE = \frac{1}{2}d \quad = \alpha_1$

When AE = 100, then $\frac{1}{2}d$ becomes $\frac{1}{2}D$.

$F''EF = d + \frac{1}{2}D \quad = \alpha_2$

$G''FG = d + D + \frac{1}{2}D = \alpha_3$, etc.

Draw EH tangent at E.

Also FN tangent at F.

The α for each chord is found by taking the *central* angle to the *beginning* of the chord plus the *deflection* angle for the chord.

$$\alpha_2 = F''EH + HEF$$
$$= d + \tfrac{1}{2}D$$
$$\alpha_3 = G''FN + NFG$$
$$= d + D + \tfrac{1}{2}D$$

$AE' = c_i \cos \alpha_1 \qquad EE' = c_i \sin \alpha_1$

$EF'' = 100 \cos \alpha_2 \qquad FF'' = 100 \sin \alpha_2$

$FG'' = 100 \cos \alpha_3 \qquad GG'' = 100 \sin \alpha_3$

$FF' = EE' + FF''$

$GG' = FF' + GG''$, etc.

For the computations indicated above, always use natural sines and cosines.

For a check, $AG' = R \sin AOG$

$GG' = R \operatorname{vers} AOG$

where O is at center of curve.

For the computations immediately above, use log sines and versines.

These "check" computations involve the radius (or degree) and the central angle; the previous computations involve the use of c also; since the formula

$$d = \frac{cD}{100} \qquad (20)$$

is an approximate formula, perfect precision in the "check" cannot be expected.

If a "check" perfectly precise is required, use formula (18) $c = 2R \sin \frac{1}{2} d$ instead of formula (20) and carry all intermediate work to the necessary degree of precision.

This method of Offsets from the Tangent is a precise method, and allows of any desired degree of precision in field-work.

Another method of finding the angles α_1, α_2, α_3, etc., is by drawing perpendiculars to the chords at K, L, and M.

Then
$$\alpha_1 = \tfrac{1}{2} d$$
$$\alpha_2 = \alpha_1 + \tfrac{1}{2} d + \tfrac{1}{2} D$$
$$= d + \tfrac{1}{2} D \text{ (as before)}$$
$$\alpha_3 = \alpha_2 + D \text{ etc.}$$

Each α being found by adding an increment to the previous value of α.

Also $\alpha_3 = \text{AOG} - \tfrac{1}{2} D$

which gives a "check" on all values of α computed.

If AE, EF, FG, are parts of a compound curve, the same general methods are applicable, except that the checks of R sin AOG and R vers AOG are not then available.

67. Field-work.

(a) Calculate AE′, E′F′, F′G′; also EE′, FF′, GG′

(b) Set E′, F′, G′, by measurements AE′, E′F′, F′G′.

(c) Set E by distance AE (c_4) and EE′.

(d) Set F " " EF (100) and FF′.

(e) Set G " " FG (100) and GG′.

68. Problem. *Given D and the stations of P.C. and P.T. Required to lay out the curve by the method of* **Deflection Distances.**

When the curve begins and ends at even stations.

In the curve AB, let

AN be a tangent

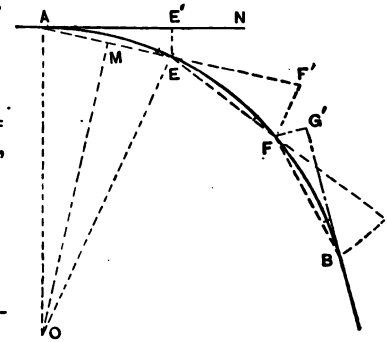
AE any chord = c

EE′ perp. to AE′ = a = "tangent deflection"

FF′ = BB′ = the "chord deflection"

AO = EO = R

Draw OM perpendicular to AE.



Then EE′ : AE = ME : EO

$$a : c = \frac{c}{2} : R \qquad \text{or } a = \frac{c^2}{2R} \qquad (26)$$

FF′ = 2 a; AF′ = AE produced

When AE is a full station of 100 feet, $a_{100} = \frac{100^2}{2R}$ (26 A)

Field-work.

The *P.C.* and *P.T.* are assumed to have been set.

(a) Calculate a_{100}.

(b) Set point E distant 100 ft. from A and distant a_{100} from AE′ (AE′ < 100 ft.; AE′E = 90°).

(c) Produce AE to F′ (EF′ = 100 ft.), and find F distant $2\,a_{100}$ from F′ (EF = 100 ft.).

(d) Proceed similarly until B is reached (*P.T.*).

(e) At station preceding B (*P.T.*) lay off FG′ = a_{100} (FG′B = 90°).

(f) G′B is tangent to the curve at B (*P.T.*).

69.. Problem. *Given the degrees of two curves having the same P.C.*

Required the offset between the two curves at the end of a given chord c.

Let D_l and R_l be the D and R of flatter curve, D_s and R_s be the D and R of sharper curve.

For 1° curve $a_1 = \frac{c^2}{2R_1}$; $a_l = \frac{c^2}{2R_l}$; $a_s = \frac{c^2}{2R_s}$

$$\frac{a_l}{a_1} = \frac{\frac{1}{R_l}}{\frac{1}{R_1}} = \frac{D_l}{D_1} \quad \text{(approx.) from (3 A)}$$

$$a_l = a_1 D_l \text{ and } a_s = a_1 D_s. \qquad (26\ B)$$

Let a_{s-l} = offset between curves $= a_s - a_l$

$$a_{s-l} = a_1 D_s - a_1 D_l$$

$$= a_1(D_s - D_l) \text{ (approx.)} \qquad (27)$$

For 1° curve and $c = 100$ $\quad a_1 = 0.873$ ft. $= \frac{7}{8}$ ft. (nearly).

$$a_{s-l} = \tfrac{7}{8}(D_s - D_l) \text{ ft. (approx.)} \qquad (27\ A)$$

70. Problem. *Given the offset to any curve for 1 chord of 100 ft.*

Required the offset for any number of chords n, each 100 ft.

$$a = \frac{c^2}{2R} \quad \text{and} \quad a_{100} = \frac{100^2}{2R} \quad \text{from (26 A)}$$

for $c = 200$ $\quad a_{200} = \frac{200^2}{2R}$; for $c = n\,100$ $\quad a_n = \frac{n^2 100^2}{2R}$

but n chords of 100 ft. each = chord n 100 (nearly) and

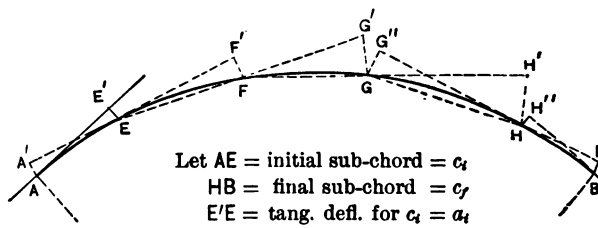
$$a_n = \frac{n^2 100^2}{2R} \quad \text{or} \quad a_n = n^2 a_{100} \quad \text{(approx.)} \qquad (28)$$

This approximation may prove too rough for most field-work unless n is very small. It may be of value in plotting. It should seldom be used for other purposes.

Similarly from (27 A) $\quad a_n = \tfrac{7}{8}(D_s - D_l)n^2$ (roughly).

71. Problem. *Given D and the stations of P.C. and P.I. Required to lay out the Curve by Deflection Distances.*

When the curve begins and ends with a sub-chord.



Let AE = initial sub-chord = c_i
HB = final sub-chord = c_f
E'E = tang. defl. for $c_i = a_i$
H''H = " " " $c_f = a_f$

by (26) $\quad a_i = \frac{c_i^2}{2R}; \quad a_f = \frac{c_f^2}{2R}; \quad a_{100} = \frac{100^2}{2R}$

$$\left.\begin{aligned} a_i : a_{100} &= c_i^2 : 100^2 & a_i &= a_{100}\frac{c_i^2}{100^2} \\ a_f : a_{100} &= c_f^2 : 100^2 & a_f &= a_{100}\frac{c_f^2}{100^2} \end{aligned}\right\} \quad (29)$$

In general it is better to use (29) than $a_i = \frac{c_i^2}{2R}$.

72. Example. *Given P.T.* 20 + 42
P.C. 16 + 25
6° curve R

Required all data necessary to lay out curve by "*Deflection Distances.*"

Calculate without Tables. Result to $\frac{1}{100}$ foot.

Radius 1° curve $= \frac{5730(6}{6°} = \frac{955}{}$

$$a_{100} = \frac{100^2}{2 \times 955} = 5.24$$

$2\,a_{100} = 10.47$

$a_{75} = 0.75^2 \times 5.24 = 2.95$

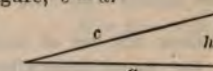
$a_{42} = 0.42^2 \times 5.24 = 0.92$

Table II. gives $a_{100} = 5.234$ (precise value)

1910)10000(5.235+
955
450
382
680
573
1070
955

The distance AE′ is slightly shorter than AE. It is generally sufficient to take the point E′ by inspection simply. If desired for this or any other purpose, a simple approximate solution of right triangles is as follows:

73. Problem. *Given the hypotenuse (or base) and altitude. Required the difference between base and hypotenuse*, or in the figure, $c - a$.



$$c^2 - a^2 = h^2$$

$$(c - a)(c + a) = h^2$$

$$c - a = \frac{h^2}{c + a} = \frac{h^2}{2c} \text{ (approx.)} = \frac{h^2}{2a} \text{ (approx.)} \qquad (30)$$

Wherever h is small in comparison with a or c, the approximation is good for ordinary purposes.

Example. $c = 100$ $\qquad c - a = \frac{100}{200} = 0.50$

$h = 10$ $\qquad a = 99.50$

The precise formula gives 99.499.

74. Field-work *for § 71.*

(*a*) Calculate a_{100}, a_i, a_f. Remember that tangent deflections are as the *squares* of the chords.

a_{100} is found in Table II., Allen, as "tangent offset."

(*b*) Find the point E, distant a_i from AE′ and distant c_i from A. (AE′E = 90°.)

(*c*) Erect auxiliary tangent at E (lay off AA′ = a_i).

(*d*) From auxiliary tangent A′E produced, find point F.

(FF′ = a_{100}; EF = 100; EF′F = 90°).

(*e*) From chord EF produced, find point G.

(GG′ = 2 a_{100}; FG′ = FG = 100).

(*f*) Similarly, for each full station, use 2 a_{100}, etc.

(*g*) At last even station on curve, H, erect an auxiliary tangent (lay off GG″ = a_{100}; GG″H = 90°).

(*h*) From G″H produced, find B (B′B = a_f, etc.).

(*i*) Find tangent at B (HH″ = a_f; HH″B = 90°).

The values of a_{100}, a_i, a_f, should be calculated to the nearest $\frac{1}{100}$ foot.

75. Caution. The tangent deflections vary as the *squares* of the chords, not directly as the chords.

Curves may be laid out by this method without a transit by the use of plumb line or "flag" for sighting in points, and with *fair* degree of accuracy.

For calculating a_{100}, a_i, a_f, it is sufficient in most cases to use the approx. value $R_a = \frac{5730}{D_a}$. A curve may be thus laid out without the use of transit or tables.

For many approximate purposes it is well and useful to remember that the "chord deflection" for 1° curve is 1.75 ft. nearly, and for other degrees in direct proportion. A head chainman may thus put himself *nearly* in line without the aid of the transitman.

The method of "Deflection Distances" is not well adapted for common use, but will often be of value in emergencies.

76. Problem. *Given D* and stations of *P. C.* and *P. T.*
Required to lay out the curve by "*Deflection Distances*" when the *first sub-chord is small.*

Caution. It will not be satisfactory in this case to produce the curve from this short chord. The method to be used can best be shown by example.

Let $PC = 41 + 90$.

Field-work.

Method 1.

(*a*) Set sta. 42 using $c = 10$ and $a_{10} = a_{100} \frac{10^2}{100^2}$.

(*b*) Set sta. 43 (100 ft. from 42) offsetting a_{110} from tangent.

(*c*) Set sta. 44 by chord produced and $2\,a_{100}$ offset.

Method 2.

(*a*) Set a point on curve produced backwards, using

$$c = 90 \text{ and } a_{90} = a_{100} \frac{90^2}{100^2}.$$

(*b*) Set sta. 42, using $c = 10$ and a_{10} as above.

(*c*) Set sta. 43 by chord produced and $2\,a_{100}$ offset.

A slight approximation is involved in each of these methods. Method 1 involves less labor.

77. Ordinates.

Problem. *Given D and two points on a curve.*

Required the *Middle Ordinate* from the chord joining the two points.

By (9), $M = R \text{ vers } \frac{1}{2} I$

for 100 ft. chord $M = R \text{ vers } \frac{1}{2} D$

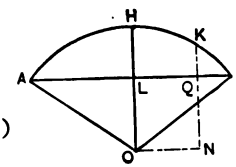
between points 2 station lengths apart $M = R \text{ vers } D.$

Let A = angle at center between any two points.

$$M = R \text{ vers } \tfrac{1}{2} A.$$

78. Problem. *Given R and c.*

Required M.



$$OL = \sqrt{R^2 - \left(\frac{c}{2}\right)^2}$$

$$HL = M = R - \sqrt{R^2 - \left(\frac{c}{2}\right)^2} \qquad (31)$$

$$M = R - \sqrt{\left(R - \frac{c}{2}\right)\left(R + \frac{c}{2}\right)} \qquad (32)$$

Table XXI., Allen, gives squares and square roots for certain numbers. If the numbers to be squared can be found in this table, use (31). Otherwise use logarithms and (32).

79. Problem. *Given R and C.*

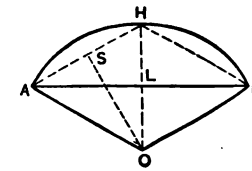
Required the *Ordinate* at any *given point* Q.

Measure $LQ = q$. Then $KN = \sqrt{R^2 - q^2}$

$$LO = \sqrt{R^2 - \left(\frac{c}{2}\right)^2}$$

$$CQ = KN - LO = \sqrt{(R+q)(R-q)} - \sqrt{\left(R + \frac{c}{2}\right)\left(R - \frac{c}{2}\right)} \qquad (33)$$

80. When $C = 100$ ft. or less, an approximate formula will generally suffice.



Problem. *Given R and c.*
Required M (approx.)

$$HL : AH = \frac{AH}{2} : R$$

$$M = \frac{AH^2}{2R}.$$

Where AB is small compared with R,

$$AH = \frac{c}{2} \text{(approx.)}$$

$$M = \frac{c^2}{8R} \text{(approx.)} \qquad (34)$$

81. Example. *Given* $C = 100$, $D = 9°$.
Required M.

$$R_9 = \frac{5730}{9} = 636.7$$

$$\begin{array}{r} 8 \\ \hline 5093.6)10000.(1.963 = M \\ 50936 \\ \hline 490640 \\ 458424 \\ \hline 322160 \\ 305616 \\ \hline 16544 \end{array}$$

Precise value
$M = 1.965$

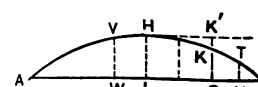
Table XXVII., Allen, gives middle ordinates for curving rails of certain lengths.

82. Problem. *Given R* and *c*.
Required Ordinate at any given point Q
Approximate Method.

I. Measure $LQ = q$

$$M = HL = \frac{\left(\frac{c}{2}\right)^2}{2R} \text{(approx.)}$$

$$KK' = \frac{HK^2}{2R}$$



$$KK' : M = HK^2 : \left(\frac{c}{2}\right)^2$$

Since $HK = q$ (approx.) $\qquad KK' = \dfrac{q^2}{\left(\frac{c}{2}\right)^2} M$ (approx.) (35)

$$KQ = M - KK'$$

When $\dfrac{q}{\frac{c}{2}} = \dfrac{1}{2}$ as in figure, $KK' = \dfrac{M}{4}$ and $KQ = \dfrac{3}{4} M$ (approx.)

When $\dfrac{q}{\frac{c}{2}} = \dfrac{1}{4}$ $\qquad VW = \dfrac{15}{16} M$ (approx.)

When $\dfrac{q}{\frac{c}{2}} = \dfrac{3}{4}$ $\qquad TU = \dfrac{7}{16} M$ (approx.)

The curve thus found is accurately a parabola, but for short distances this practically coincides with a circle.

83. II. *Approximate Method.* Measure LQ and QB

$$M = \frac{\left(\frac{c}{2}\right)^2}{2R} \qquad KK' = \frac{q^2}{2R} \text{ (approx.) from} \quad (26)$$

$$KQ = \frac{\left(\frac{c}{2}\right)^2 - q^2}{2R} = \frac{\left(\frac{c}{2} + q\right)\left(\frac{c}{2} - q\right)}{2R} \text{ (approx.)}$$

$$KQ = \frac{AQ \times QB}{2R} \text{ (approx.)} \quad (36)$$

Sometimes one, sometimes the other of these methods will be preferable.

84. Example. *Given* $C = 100$, $D = 9°$.
$M = 1.965$ from Tables.
Required, Ordinate at point 30 *ft. distant from center toward end of chord.*

I. $30 \text{ ft.} = \dfrac{30}{50} \times \dfrac{C}{2}$

$KK' = \dfrac{9}{25} \times 1.965$

$25)\overline{17.685}$

$.70740$

$M = 1.965$

Ordinate $= 1.258$

Precise result for data above $= 1.260$.

II.

$AQ = 80$

$BQ = 20$

$1273.4)\overline{1600}(1.25$

1273.4

32660

25468

71920

63670

8250

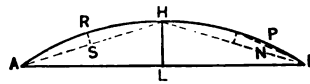
$R_1 = 5730.$

$R_9 = 636.7$

$2\,R_9 = 1273.4$

85. Problem. *Given R and c.*

Required a series of points on the curve.



$$M = HL = \frac{c^2}{8R} \text{ (approx.)}$$

$$RS = \frac{AH^2}{8R} \text{ (approx.)} \qquad AH = \frac{c}{2} \text{ (approx.)}$$

$$RS = \frac{\frac{c^2}{4}}{8R} = \frac{M}{4} \text{ (approx.)}$$

$$PN = \frac{RS}{4} \text{ (approx.), etc., as far as desirable.}$$

This method is useful for many general purposes, for ordinates in bending rails among others.

86. Problem. *Given a Simple Curve joining two tangents.*

Required the *P.C.* of a *new curve* of the *same radius* which shall end in a *parallel tangent.*

Let AB be the given curve.

A′B′ " " required curve.

B′E = p = perpendicular distance between tangents.

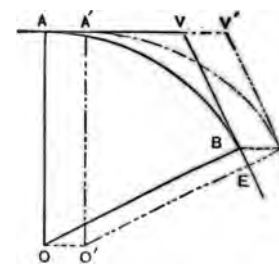
Join BB′.

Then AA′ = OO′ = BB′

Also B′BE = V′VB = I

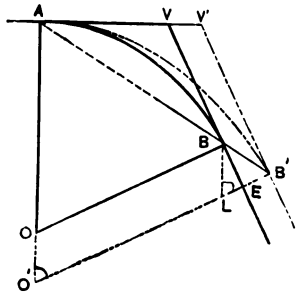
$$BB' \sin I = p$$

$$BB' = AA' = \frac{p}{\sin I} \qquad (37)$$



When the proposed tangent is *outside* the original tangent, the distance AA is to be added to the station of the *P.C.* When *inside*, it is to be subtracted.

87. Problem. *Given a Simple Curve joining two tangents. Required* the *Radius* of a new curve which with the *same P.C.* shall end in a *parallel tangent.*



Let AB be the given curve of radius R = AO.

B'E = p = perpendicular distance.

AB' the required curve, radius = R'.

Draw chords AB, AB';

also line BB';

also BL parallel to AO.

Then $BLB' = AO'B' = I$

$BL = OO'$

$= R' - R$

$= B'L$

Therefore BL vers BLB' = B'E

$(R' - R)$ vers $I = p$

$$(R' - R) = \frac{p}{\text{vers } I} \tag{38}$$

Since VAB = V'AB', AB and AB' are in the same straight line.

And with transit at A, point B' can be set by measuring BB' in direction AB.

Also $$BB' = \frac{B'E}{\sin B'BE} \quad \text{or} \quad BB' = \frac{p}{\sin \frac{1}{2} I} \tag{39}$$

When the proposed tangent is *outside* the original tangent (as it is shown in the figure), the above formula applies, and

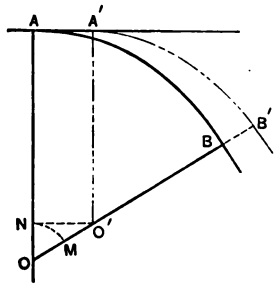
$$R' > R.$$

When the proposed tangent is *inside* the original tangent, the formula becomes

$$R - R' = \frac{p}{\text{vers } I} \tag{40}$$

and $R' < R$.

88. Problem. *Given a Simple Curve joining two tangents. Required the radius and P.C. of a new curve to end in a parallel tangent with the new P.T. directly opposite the old P.T.*



Let AB be the given curve of radius $= R$.

A'B' the required curve of radius R'.

$BB' = p$.

Draw perpendicular O'N and arc NM

Then $O'M = B'M - B'O'$

$= B'M - BM = BB'$

$O'M = p$

$ON \quad \text{exsec } NOO' = O'M$

$$(R - R') \text{ exsec } I = p; \quad R - R' = \frac{p}{\text{exsec } I} \tag{41}$$

$$AA' = O'N = ON \tan NOO'$$

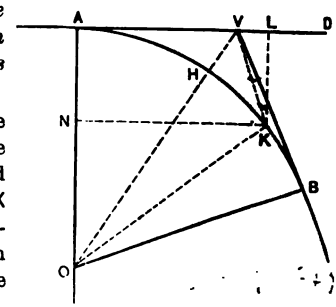
$$AA' = (R - R') \tan I \tag{42}$$

When the new tangent is *outside* the original tangent (as in the figure), $R > R'$ and AA' is added to the station of the *P.C.*

When the new tangent is *inside* the original tangent, $R < R'$, $R' - R = \frac{p}{\text{exsec } I}$, and AA' is subtracted from station of *P.C.*

89. Problem. *To find the Simple Curve that shall join two given tangents and pass through a given point.*

With the transit at V, the given point K can often be best fixed by angle BVK and distance VK. If the point K be fixed by other measurements, these generally can readily be reduced to the angle BVK and distance VK.



90. Problem. *Given the two tangents intersecting at V, the angle I, and the point* K *fixed by angle* BVK $= \beta$ *and distance* VK $= b$.
Required the radius R *of curve to join the two tangents and pass through* K.

In the triangle VOK we have given

$$\text{VK} = b \text{ and } \text{OVK} = \frac{180 - I}{2} - \beta$$

Further $\quad \text{VO} = \dfrac{R}{\cos \frac{1}{2} I} \qquad \text{OK} = R$

$$\text{VO} : \text{OK} = \sin \text{VKO} \ : \ \sin \text{OVK}$$

$$\frac{R}{\cos \frac{1}{2} I} : R = \sin \text{VKO} \ : \ \cos(\tfrac{1}{2} I + \beta)$$

$$\sin \text{VKO} = \frac{\cos(\frac{1}{2} I + \beta)}{\cos \frac{1}{2} I} \qquad (43)$$

From data thus found, the triangle VOK may be solved for R.

In solving this triangle the angle VOK is often very small. A slight error in the value of this small angle may occasion a large error in the value of R. In this case use the following **Second Method** of finding R after VOK has been found.

Find $\quad \text{AOK} = \frac{1}{2} I + \text{VOK} \qquad$ Also $\text{DVK} = I + \beta$

Then $\quad R \text{ vers AOK} = \text{LK}$

$$= b \sin \text{DVK}$$

$$R = \frac{b \sin \text{DVK}}{\text{vers AOK}} \qquad (44)$$

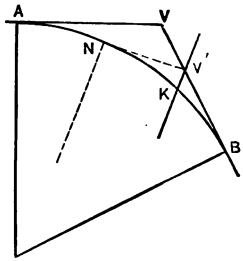
91. Problem. *Given* R, I, β (BVK).
Required b (VK).

In the triangle VOK

$$\text{OK} = R; \quad \text{OV} = \frac{R}{\cos \frac{1}{2} I}$$

$$\text{OVK} = 90 - (\tfrac{1}{2} I + \beta)$$

Solve triangle for b.
Also find VOK and station of K if desired.



92. Problem. *To find the point where a straight line intersects a curve between stations.*

Find where the straight line V'K cuts VB at V'.

Measure KV'B.

Use V' as an auxiliary vertex.

Find *I'* from V'B by (5).

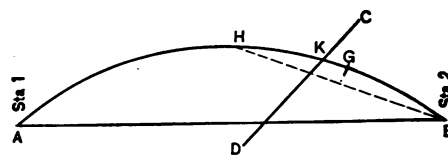
Solve by preceding problem.

93. Approximate Method.

Set the middle point H by method of ordinates.

If the arc HB is sensibly a straight line, find the intersection of HB and CD.

Otherwise set the point G by method of ordinates, and get intersection of HG and CD.

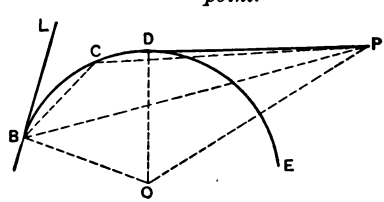


Additional points on the arc may be set if necessary, and the process continued until the required precision is secured.

The points H and G can be set without the use of a transit with sufficient accuracy for many purposes, a plumb line or flag being used in "sighting in."

94. Problem. *Given a Simple Curve and a point outside the curve.*

Required a tangent to the curve from that point.



Let BDE be the given curve.

P the point outside the curve.

BL a tangent at B.

Measure LBP, also BP.

In the triangle BPO we have given PBO, BP, BO.

Solve the triangle for BOP and OP.

Then $$\cos \text{DOP} = \frac{\text{OD}}{\text{OP}} = \frac{R}{\text{OP}}$$

$$\text{BOD} = \text{BOP} - \text{DOP}$$

From BOD find station of D from known point B.

It should be noted that if *log* OP is found, this can be used again without looking out the number for OP. Other similar cases will occur elsewhere in calculation.

When for any reason it is difficult or inconvenient to measure BP directly, the angles CBP, BCP and the distance BC may be measured and BP calculated.

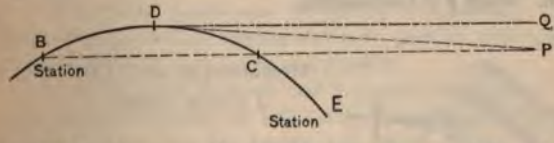
94 A. Tentative Method.

Field-work.

(*a*) From the station (B) nearest to the required point D, find by the approximate method where BP cuts the curve at C. (If E be the nearest station, produce PC to B.)

(*b*) Assume D with BD slightly greater than CD, and with transit at *P. C.* set the point D (transit point) truly on the curve.

(*c*) Move the transit to D, and lay off a tangent to the curve at D. This will very nearly strike P.

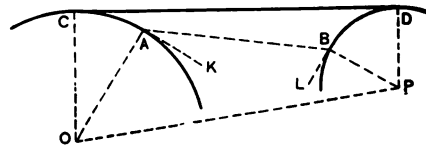


(*d*) If the tangent strikes away from P, at Q, measure QDP, and move the point D (ahead or back as the case may be) a distance *c* due to an angle at the center $d = \text{QDP}$. The tangent from this new point ought to strike P almost exactly.

In a large number of cases the point D will be found on the first attempt sufficiently close for the required purpose.

If a tangent between two curves is required, similar methods by approximation will be found available.

95. Problem. *Given two Simple Curves.*
Required a tangent to both Curves.



Find convenient points A and B on the given curves.

Let AK and BL be tangents.

Measure line AB and angles BAK and ABL.

Let AO = R_1 and BP = R_2 (both given).

Solve ABPO for line OP and angles AOP and BPO.

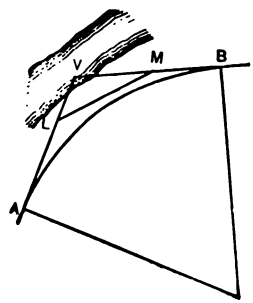
Then, $\cos COP = \frac{R_1 - R_2}{OP}$ and $DPO = 180° - COP$.

$$AOC = COP - AOP; \qquad BPD = DPO - BPO.$$

When a tangent is to connect two tracks already laid, it may be determined by a process similar to **94 A** by tentative method.

Obstacles on Curves.

96. When *V* is inaccessible.



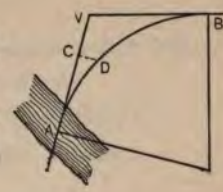
Measure VLM, VML, LM.

$I = VLM + VML$

LV and VM are readily calculated, and AL and MB determined.

In some cases the best way is to assume the position of *P.C.* and run out the curve as a trial line, and finally find the position of *P.C.* correctly by the method of formula (37).

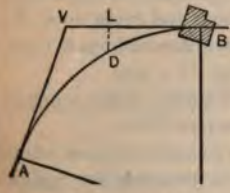
97. When the *P.C.* is inaccessible.



Establish some point D (an even station is preferable) by method of "offsets from Tangent" or otherwise.

Move transit to B (*P.T.*) and run out curve starting from D and checking on tangent VB.

98. When the *P.T.* is inaccessible.



With instrument still at *V*, set some convenient point D, move transit to *P.C.*, and run in curve to D, and then pass the obstacle at B as any obstacle on a tangent would be passed.

99. When **Obstacles on the Curve** occur so as to prevent running in the curve, no general rules can well be given. Sometimes *resetting* the transit in the curve will serve. Sometimes, if one or two points only are invisible from the transit, these can be set by "*deflection distances*," and the curve continued by "*deflection angles*," without resetting the transit. Sometimes "*offsets from the tangent*" can be used to advantage. Sometimes points can be set by "*ordinates*" from chords. Sometimes the method shown on page 54, § 92, assuming an auxiliary *V*, is the only one possible.

It should be borne in mind that it is seldom *necessary* that the *full stations* should be set. If it be possible to set any points whose stations are known and which are not too far apart, this is generally sufficient.

Finally, for passing obstacles and for solving many problems which occasionally occur, it is necessary to understand the various methods of laying out curves, and to be familiar with the mathematics of curves; and, in addition, to exercise a reasonable amount of ingenuity in the application of the knowledge possessed.

CHAPTER V.

COMPOUND CURVES.

100. When one curve follows another, the two curves having a common tangent at the point of junction, and lying upon the same side of the common tangent, the two curves form a *Compound Curve.*

When two such curves lie upon opposite sides of the common tangent, the two curves then form a *Reversed Curve.*

In a compound curve, the point at the common tangent where the two curves join, is called the *P.C.C.*, meaning the "point of compound curvature."

In a reversed curve, the point where the curves join is called the *P.R.C.*, meaning the "point of reversed curvature."

Field-work.

Laying out a compound curve or a reversed curve.

(*a*) Set up transit at *P.C.*

(*b*) Run in simple curve to *P.C.C.* or *P.R.C.*

(*c*) Move transit to *P.C.C.* or *P.R.C.*

(*d*) Set line of sight on common tangent with vernier at 0° by method of § 60.

(*e*) Run out second curve as a simple curve.

Data Used in Compound Curve Formulas.

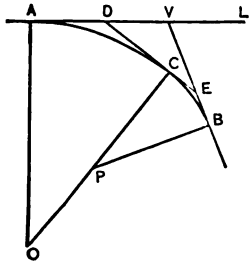
In the curve of larger radius, OA = R_1; AOC = I_1; AV = T_1.

In the curve of shorter radius, PB = R_2; BPC = I_2; VB = T_2;

Also LVB = I.

101. Problem. *Given* R_1, R_2, I_1, I_2.

Required I, T_1, T_2.



Draw the common tangent DCE.

Then $I = I_1 + I_2$

$AD = CD = R_1 \tan \frac{1}{2} I_1$

$EB = CE = R_2 \tan \frac{1}{2} I_2$

or find CD and CE, using Allen's Table III. and the correction, Table IV.

In the triangle DVE we have one side and three angles

$$DE = R_1 \tan \tfrac{1}{2} I_1 + R_2 \tan \tfrac{1}{2} I_2 \qquad (45)$$

$VDE = I_1$; $VED = I_2$; and $DVE = 180 - I$

Solve for VD and VE then $AV = AD + VD = T_1$

$VB = BE + VE = T_2$

102. Problem. *Given* T_2, R_2, I_2, I.

Required T_1, R_1, I_1.

$I_1 = I - I_2$.

Find $CE = EB$ from D_2 and I_2 (Tables III. and IV.)

Having given VE and all three angles

Solve for DE and DV; also find CD.

Then $T_1 = AV = CD + DV$

Also $R_1 = \dfrac{CD}{\tan \frac{1}{2} I_1}$

103. Problem. *Given* T_1, R_1, I_1, I.

Required T_2, R_2, I_2.

$I_2 = I - I_1$.

Find $AD = DC$ from D_1 and I_1 (Tables III. and IV.)

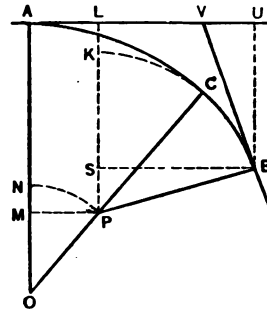
Having given DV and all three angles

Solve for DE and VE; also find CE.

Then $T_2 = VB = VE + CE$; and $R_2 = \dfrac{CE}{\tan \frac{1}{2} I_2}$

See § 105 and § 108 for other solutions of § 102 and § 103.

104. Problem. *Given* T_s, R_s, R_l, I.
Required T_l, I_l, I_s.



Draw arcs NP and KC.

Draw perpendiculars MP, LP, SB, UB.

Then $AM = LP$

$AN = R_s = KP$

$NM = LK = LS - KS$

$OP \text{ vers } NOP = VB \sin VBS - PB \text{ vers } KPB$

$(R_l - R_s) \text{ vers } I_l = T_s \sin I - R_s \text{ vers } I$

$$\text{vers } I_l = \frac{T_s \sin I - R_s \text{ vers } I}{R_l - R_s} \tag{46}$$

$$I_s = I - I_l$$

$AV = MP + SB - UV$

$$T_l = (R_l - R_s) \sin I_l + R_s \sin I - T_s \cos I \tag{47}$$

105. Problem. *Given* T_s, R_s, I_s, I.
Required T_l, R_l, I_l.

$$I_l = I - I_s$$

$$R_l - R_s = \frac{T_s \sin I - R_s \text{ vers } I}{\text{vers } I_l} \tag{48}$$

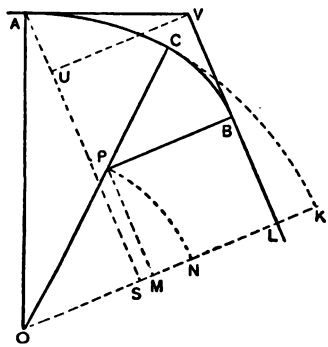
$$T_l = (R_l - R_s) \sin I_l + R_s \sin I - T_s \cos I \tag{49}$$

106. Problem. *Given* T_l, T_s, R_s, I.
Required R_l, I_l, I_s.

$$\tan \tfrac{1}{2} I_l = \frac{T_s \sin I - R_s \text{ vers } I}{T_l + T_s \cos I - R_s \sin I} \tag{50}$$

$$R_l - R_s = \frac{T_l + T_s \cos I - R_s \sin I}{\sin I_l} \tag{51}$$

In $\triangle NMP$, $\tan NPM = \frac{NM}{MP} = \tan \frac{1}{2} I_l$



107. Problem.

Given T_1, R_1, R_2, I.

Required T_2, I_1, I_2.

Draw arcs NP, KC.

Draw perpendiculars OK, AS, PM, VU.

Then $LM = BP = KN$

$MN = LM - LN = KN - LN = KL$

$LK = MN = KS - LS$

OP vers NOP = AO vers AOK − AV sin VAS

$(R_1 - R_2)\operatorname{vers} I_2 = R_1 \operatorname{vers} I - T_1 \sin I$

$$\operatorname{vers} I_2 = \frac{R_1 \operatorname{vers} I - T_1 \sin I}{R_1 - R_2} \tag{52}$$

$$I_1 = I - I_2$$

VB = AS − PM − AU

$$T_2 = R_1 \sin I - (R_1 - R_2)\sin I_2 - T_1 \cos I \tag{53}$$

108. Problem. *Given* T_1, R_1, I_1, I.

Required T_2, R_2, I_2.

$$I_2 = I - I_1$$

$$R_1 - R_2 = \frac{R_1 \operatorname{vers} I - T_1 \sin I}{\operatorname{vers} I_2} \tag{54}$$

$$T_2 = R_1 \sin I - (R_1 - R_2)\sin I_2 - T_1 \cos I \tag{55}$$

109. Problem. *Given* T_1, T_2, R_1, I.

Required R_2, I_1, I_2.

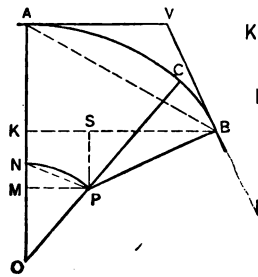
$$\tan \tfrac{1}{2} I_2 = \frac{R_1 \operatorname{vers} I - T_1 \sin I}{R_1 \sin I - T_1 \cos I - T_2} \tag{56}$$

$$R_1 - R_2 = \frac{R_1 \sin I - T_1 \cos I - T_2}{\sin I_2} = \frac{PM}{\sin PSM}$$

In $\triangle NPM$ $NM = LK$ $\therefore \tan \tfrac{1}{2} I_2 =$

$$\frac{LK}{DM}$$

110. Problem. *Given, in the figure,* AB, VAB, VBA, R_s.
Required R_l, I_l, I_s, I.



Draw arc NP; also perpendiculars KB, MP, SP.

$$I = \text{VAB} + \text{VBA}$$

$$\begin{aligned}\text{NM} &= \text{AK} + \text{KM} - \text{AN}\\ &= \text{AB sin VAB} + \text{PB cos SPB} - \text{AN}\\ &= \text{AB sin VAB} + R_s \cos I - R_l\\ &= \text{AB sin VAB} - R_s \operatorname{vers} I\end{aligned}$$

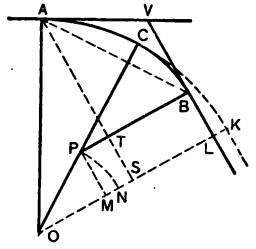
$$\begin{aligned}\text{MP} &= \text{KB} - \text{SB}\\ &= \text{AB cos VAB} - \text{PB sin SPB}\\ &= \text{AB cos VAB} - R_s \sin I\end{aligned}$$

$$\tan \text{NPM} = \tan \tfrac{1}{2} I_l = \frac{\text{NM}}{\text{MP}} \qquad (58)$$

$$I_s = I - I_l$$

$$\text{OP} = R_l - R_s = \frac{\text{MP}}{\sin I_l} \qquad (59)$$

111. Problem. *Given, in the figure,* AB, VAB, VBA, R_l.
Required R_s, I_l, I_s, I.



Draw arc PN; also perpendiculars PM, AS.

$$I = \text{VAB} + \text{VBA}$$

$$\begin{aligned}\text{NM} = \text{LK} &= \text{SK} - \text{SL}\\ &= \text{OA vers AOK} - \text{AB sin VBA}\\ &= R_l \operatorname{vers} I - \text{AB sin VBA}\end{aligned}$$

$$\begin{aligned}\text{MP} &= \text{AS} - \text{AT}\\ &= \text{OA sin AOK} - \text{AB cos VBA}\\ &= R_l \sin I - \text{AB cos VBA}\end{aligned}$$

$$\tan \text{NPM} = \frac{\text{NM}}{\text{MP}} \qquad (60)$$

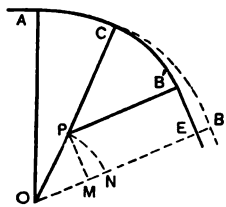
$$\tan \tfrac{1}{2} I_s = \frac{\text{NM}}{\text{MP}}$$

$$I_l = I - I_s \qquad (61)$$

$$\text{OP} = R_l - R_s = \frac{\text{MP}}{\sin I_s}$$

112. Problem. *Given a Simple Curve ending in a given tangent.*

A second curve of given radius is to leave this and end in a given parallel tangent.



Required the P. C. C.

Let AB be the given curve of radius R_l.

C be the *P. C. C.*

CB′ the second curve of radius R_s.

BE $= p =$ distance between tangents.

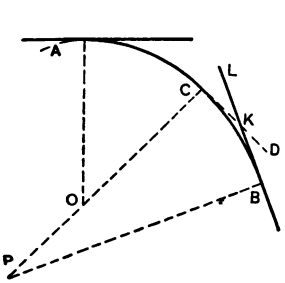
Then MN = EB $= p$.

$$\text{vers COB} = \frac{\text{MN}}{\text{OP}}$$

$$\text{vers COB} = \frac{p}{R_l - R_s} \qquad (62)$$

113. *Given, a Simple Curve of radius R_1; also a line not tangent to this curve.*

Required, the radius R_2 of a second curve to connect a given point on this curve as a P. C. C., with the given line as a tangent.



Let AC be the given curve of radius R_1.

LB the given line.

C be a point selected (as convenient or necessary) as the given *P. C. C.*

CB the required curve of radius R_2.

From C lay off auxiliary tangent CD cutting LB at K.

Measure CK and angle DKB

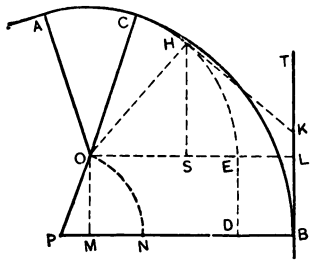
$$\text{Then } R_2 = \frac{\text{CK}}{\tan \frac{1}{2} \text{DKB}} \qquad (63)$$

$$\text{KB} = \text{CK}$$

This fixes the position of B, the *P. T.*, thus allowing a "check" on the field-work.

114. *Given a Simple Curve of radius R_1; also a line not tangent to this curve.*

Required, the P. C. C. of a second curve of given radius R_2 to leave this curve and join the given line as a tangent.



Let ACHE be the given curve.

TB the given line.

AO radius R_1.

PC radius R_2.

CB required second curve.

C required *P. C. C.*

From a convenient point H on the given curve lay off auxiliary tangent HK cutting TB at K.

Measure HK and angle TKH.

Then $HOL = TKH$

$$LE = SL - SE$$

$$= HK \sin TKH - OH \text{ vers } HOL$$

$$p = HK \sin TKH - R_1 \text{ vers } TKH$$

Also $DB = MB - MD$

$$MN = MB - NB = DB = p$$

$$MN = PO \text{ vers } OPN$$

$$\frac{p}{(R_2 - R_1)} = \text{vers } I_2 \qquad (64)$$

The angle AOH is given.

$$CPB - TKH = COH$$

$$AOH - COH = AOC = I_1$$

This serves to fix station of *P. C. C.* at C.

Also $KB = KL + LB$

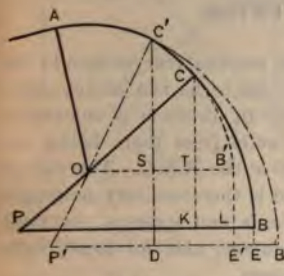
$$= HS - HK \cos TKH + LB$$

$$= OH \sin TKH - HK \cos TKH + OP \sin OPN$$

$$KB = R_1 \sin TKH - HK \cos TKH + (R_2 - R_1) \sin I_2$$

115. Problem. *Given a Compound Curve ending in a given tangent.*

Required to change the P.C.C. so as to end in a *given parallel tangent, the radii remaining unchanged.*



I. When the *new tangent* lies *outside* the *old tangent*, and the *curve ends* with curve of *larger radius.*

Let ACB be the given compound curve.

AC'B'' the required curve.

Produce C'O to P', draw arc C'B'' and connect P'B''.

Produce arc AC to B' and connect OB'.

Draw perpendiculars C'SD, CTK, B'LE', and BE.

Then $EB'' = E'B'' - LB$

$= DB'' - SB' - (KB - TB')$

$= P'C'$ vers $C'P'B'' - OC'$ vers $C'OB'$

$-$ (PC vers CPB $-$ OC vers COB')

$$p = (R_l - R_s) \text{ vers } I_l' - (R_l - R_s) \text{ vers } I_l$$

$$\frac{p}{R_l - R_s} = \text{vers } I_l' - \text{vers } I_l. \tag{65}$$

116. II. When the *new tangent* lies *inside* the *old tangent*, and the *curve ends* with the curve of *larger radius.*

$$\frac{p}{R_l - R_s} = \text{vers } I_l - \text{vers } I_l'. \tag{66}$$

117. III. When the *new tangent* lies *outside* the *old tangent*, and the *curve ends* with curve of *smaller radius.*

With a new figure it may be shown that

$$\frac{p}{R_l - R_s} = \text{vers } I_s - \text{vers } I_s' \tag{67}$$

118. IV. When the *new tangent* lies *inside* the *old tangent*, and the *curve ends* with curve of *smaller radius.*

$$\frac{p}{R_l - R_s} = \text{vers } I_s' - \text{vers } I_s \tag{68}$$

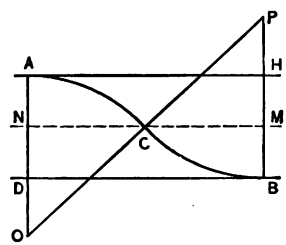
CHAPTER VI.

REVERSED CURVES.

It is considered undesirable that reversed curves should be used on main lines, or where trains are to be run at any considerable speed. The marked change in direction is objectionable, and an especial difficulty results from there being no opportunity to elevate the outer rail at the *P.R.C.* The use of reversed curves on lines of railroad is therefore very generally condemned by engineers. For yards and stations, reversed curves may often be used to advantage, also for street railways, and perhaps for other purposes.

119. Problem. *Given the perpendicular distance between parallel tangents, and the common radius of the reversed curve.*

Required the central angle of each curve.



Let AH and BD be the parallel tangents.

ACB the reversed curve.

HB = p = perpendicular distance between tangents.

Draw perpendicular NM.

Let AOC = BPC = I_r.

Then $$\text{vers AOC} = \frac{\text{AN}}{\text{AO}} = \frac{\text{BM}}{\text{PB}} = \frac{\frac{1}{2}\text{HB}}{\text{AO}}$$

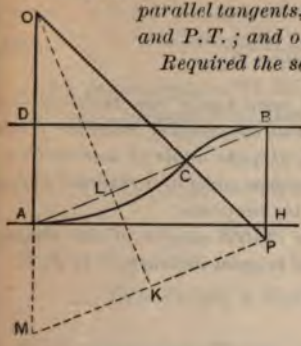
$$\text{vers } I_r = \frac{\frac{1}{2}p}{R} \tag{69}$$

120. Problem. *Given p, I_r.*

Required R.

$$R = \frac{\frac{1}{2}p}{\text{vers } I_r} \tag{70}$$

121. Problem. *Given the perpendicular distance p between parallel tangents, the chord distance d between P.C. and P.T.; and one radius R_1 of a reversed curve. Required the second radius R_2.*



Let ACB = reversed curve.
AH, DB parallel tangents.
AB = d BH = p
OA = R_1 and PB = R_2
Connect AC and CB.
AOC = BPC and ACO = PCB
ACB is a straight line.
Draw MP parallel to AB, OK perpendicular to MP.
MP = AB and AM = BP

OM : MK = AB : BH

$$R_1 + R_2 : \tfrac{1}{2}d = d : p \qquad \text{or } R_1 + R_2 = \frac{d^2}{2p} \tag{71}$$

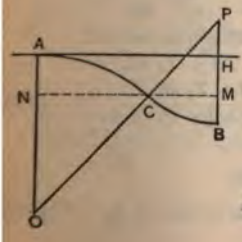
When $R_1 = R_2 = R$ $$R = \frac{d^2}{4p} \tag{72}$$

122. Problem. *Given R and p. Required d.*

From (72 *A*) $$d = \sqrt{2(R_1 + R_2)p} \tag{73}$$

When $R_1 = R_2 = R$ $$d = \sqrt{4Rp} = 2\sqrt{Rp} \tag{74}$$

123. Problem. *Given the perpendicular distance between two parallel tangents, and the central angle and radius of first curve of reversed curve.*
Required the radius of second curve.



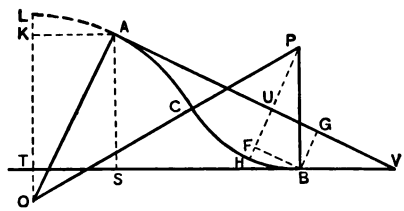
Let ACB = reversed curve
HB = p; AO = R_1; PB = R_2
AOC = CPB = I_r
Draw perpendicular NCM.
HB = AN + MB
= AO vers AOC + BP vers BPC
$p = R_1$ vers $I_r + R_2$ vers I_r

$$R_1 + R_2 = \frac{p}{\text{vers } I_r} \tag{75}$$

124. Problem. *Given R_1, R_2, p.*
Required I_r.

from (75) $$\text{vers } I_r = \frac{p}{R_1 + R_2} \tag{76}$$

125. Problem. *Given a P. C. upon one of two tangents not parallel, also the tangent distance from P. C. to V, also the angle of intersection, also the unequal radii of a reversed curve to connect the tangents.*
Required the central angles of the simple curves, and tangent distance, V to P. T.



Let AV $= T_1$ = given tangent distance
ACB = required curve
AOC $= I_1$, BPC $= I_2$ } required angles
BV $= T_2$ = required tangent distance

A = given *P. C.*
V = vertex
AVT $= I$
AO $= R_1$, PB $= R_2$ } given radii
VT = second tangent

Draw arc AL, also perpendiculars OL, AS, AK.

Then LT $= p$ = perpendicular distance between parallel tangents and by (75) $p =$ $(R_1 + R_2)$ vers LOC

LT = LK + AS

$(R_1 + R_2)$ vers LOC = AO vers AOL + AV sin AVS

$(R_1 + R_2)$ vers $I_2 = R_1$ vers $I + T_1 \sin I$

$$\text{vers } I_2 = \frac{R_1 \text{ vers } I + T_1 \sin I}{R_1 + R_2} \tag{77}$$

$$I_1 = I_2 - I$$

BV = VS + AK − TB

$$T_2 = T_1 \cos I + R_1 \sin I - (R_1 + R_2) \sin I_2 \tag{78}$$

126. Problem. *Given* BV *instead of* AV, *and other data as above.*
Required I_1, I_2, *etc.*

Draw perpendiculars PH, BF, BG.
UH = p = perpendicular distance between parallel tangents.

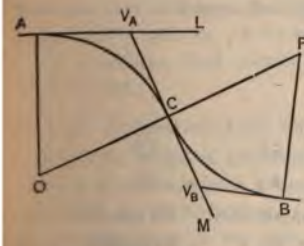
$$\begin{aligned} \text{UH} &= \text{FH} + \text{GB} \\ (R_1 + R_2) \operatorname{vers} I_1 &= R_2 \operatorname{vers} I + T_2 \sin I \\ \operatorname{vers} I_1 &= \frac{R_2 \operatorname{vers} I + T_2 \sin I}{R_1 + R_2} \end{aligned} \tag{79}$$

$$T_1 = T_2 \cos I + R_2 \sin I + (R_1 + R_2) \sin I_1 \tag{80}$$

Many problems in reversed curves can be simply and quickly solved by using the available data in a way to bring the problem into a shape where it becomes a case of parallel tangents with p known, and which can be solved by (75).

This is true particularly of sidings and yard problems.

127. Problem. *Given the length of the common tangent and the angles of intersection with the separated tangents.*
Required the common radius of a reversed curve to join the two separated tangents.

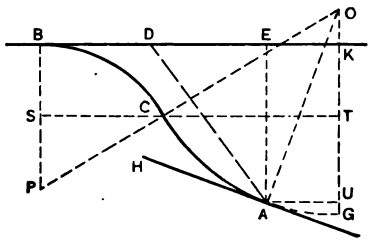


Let V_AV_B = common tangent
AV_A, BV_B = separated tangents
ACB = required curve
$LV_AC = I_A$; $MV_BB = I_B$
$V_AV_B = l$

$$\begin{aligned} V_AV_B &= V_AC + V_BC \\ l &= R \tan \tfrac{1}{2} I_A + R \tan \tfrac{1}{2} I_B \\ R &= \frac{l}{\tan \frac{1}{2} I_A + \tan \frac{1}{2} I_B} \end{aligned} \tag{81}$$

An approximate method is as follows :—
Find T_{A1} for a 1° curve ; also T_{B1} (Table III.)

Then $$D_a = \frac{T_{A1} + T_{B1}}{V_AV_B} \qquad \text{(approx.)}$$



128. *Given, for a versed curve, the P lying on a given t gent; also the posit of another tangent parallel; also the equal radii, R_1 and of the reversed curv Required the cen angles I_1 and I_2; also I; also the position of P.T.*

Let ACB be the reversed curve
AH, BK, the given tangents
A, the given *P.C.*
AOC $= I_1$
CPB $= I_2$

Measure from A to some convenient point D on BK; let AD=
Measure also HAD and ADK.
Then the angle between tangents = ADK − HAD $= I$.
Extend arc CA to G where curve is parallel to BK.
Draw perpendiculars AE, OG, AU, SCT.

Then KG = AE + UG
$= AD \sin ADK + OA \text{ vers } AOG$
$p = b \sin ADK + R_1 \text{ vers } I$

From (76) $\frac{p}{R_1+R_2} = \text{vers } I_2$
$I_1 = I_2 - I$

Also BD = BK − EK − ED
= ST − AU − ED
= OP sin CPB − OA sin AOG − AD cos ADK
$= (R_1 + R_2) \sin I_2 - R_1 \sin I - b \cos ADK$

Tower

CHAPTER VII.

PARABOLIC CURVES.

129. Instead of circular arcs to join two tangents, parabolic arcs have been proposed and used, in order to do away with the sudden changes in direction which occur where a circular curve leaves or joins a tangent. Parabolic curves have, however, failed to meet with favor for railroad curves for several reasons.

1. Parabolic curves are less readily laid out by instrument than are circular curves.

2. It is not easy to compute at any given point the radius of curvature for a parabolic curve ; it may be necessary to do this either for curving rails or for determining the proper elevation for the outer rail.

3. The use of the "Spiral," or other "Easement," or "Transition" curves secures the desired result in a more satisfactory way.

There are however many cases (in Landscape Gardening or elsewhere) where a parabolic curve may be useful either because it is more graceful or because, without instrument, it is more easily laid out, or for some other reason.

It is seldom that parabolic curves would be laid out by instrument.

130. Properties of the Parabola.

(*a*) The locus of the middle points of a system of parallel chords of a parabola is a straight line parallel to the axis of the parabola (*i.e.* a diameter).

(*b*) The locus of the intersection of pairs of tangents is in the diameter.

(*c*) The tangent to the parabola at the vertex of the diameter is parallel to the chord bisected by this diameter.

(*d*) Diameters are parallel to the axis.

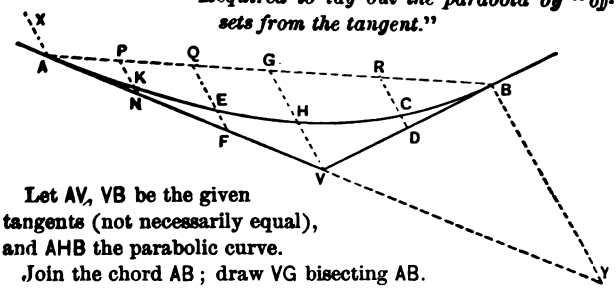
(*e*) **The equation of the parabola, the coördinates measured upon the diameter and the tangent at the end of the diameter is**

$$y'^2 = \frac{4p}{\sin^2\theta} x'$$

or

$$y^2 = 4p'x \tag{82}$$

131. Problem. *Given two tangents to a parabola, also the position of P.C. and P.T.*
Required to lay out the parabola by "offsets from the tangent."



Let AV, VB be the given tangents (not necessarily equal), and AHB the parabolic curve.

Join the chord AB; draw VG bisecting AB.

Draw AX, BY, parallel to VG; produce AV to Y.

Then VG is a diameter of the parabola.

AX parallel to VG is also a diameter.

The equation of the parabola referred to AX and AY as axes is

$$y^2 = 4p'x.$$

Instead of solving this equation engineers commonly use the proportion

$$y_1^2 : y_2^2 = x_1 : x_2 \tag{83}$$

Hence

$$AV^2 : AY^2 = HV : BY$$
$$AV^2 : (2\,AV)^2 = HV : 2\,GV$$
$$1 : 4 = HV : 2\,GV$$
$$HV = \frac{GV}{2} \tag{84}$$

Next bisect VB at D.

Draw CD parallel to AX.

Then

$$BD^2 : BV^2 = CD : HV$$
$$CD = \frac{HV}{4}$$

Similarly, make $AN = NF = FV$

Then $KN = \frac{HV}{9}$

$EF = \frac{4}{9}HV$

In a similar way, as many points as are needed may be found.

132. Field-work.

(*a*) Find G bisecting AB.

(*b*) Find H bisecting GV.

(*c*) Find points P, Q, and N, F, dividing AG, AV, proportionately; also R and D, dividing GB and BV proportionately. Use simple ratios when possible (as $\frac{1}{2}$, $\frac{1}{3}$, etc.).

(*d*) Lay off on PN, the calculated distance KN

on QF lay off EF

on RD lay off CD

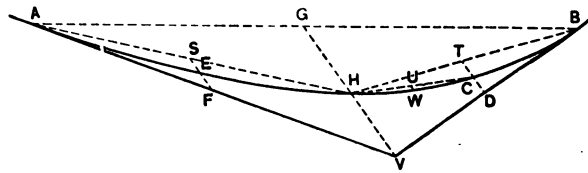
In figure opposite, $KN = \frac{HV}{9}$

$CD = \frac{HV}{4}$

$EF = \frac{4}{9}HV$

For many purposes, or in many cases, it will give results sufficiently close, to proceed without establishing P, Q, R; the directions of NK, EF, CD, being given approximately by eye. When the angle AVG is small (as in the figure), it will generally be necessary to find P, Q, R, and fix the directions in which to measure NK, EF, CD. When the angle AVG is large (greater than 60°) and the distances NK, EF, CD are not large, it will often be unnecessary to do this. No fixed rule can be given as to when approximate methods shall be used. Experience educates the judgment so that each case is settled upon its merits.

133. Problem. *Given two tangents to a parabola, also the positions of P. C. and P. T.*
Required to lay out the parabola by "middle ordinates."



The ordinates are taken from the middle of the chord, and parallel to GV in all cases.

Field-work.

(*a*) Establish H as in last problem.

(*b*) Lay off SE = ½ HV; also TC = ½ HV.

(*c*) Lay off UW = ¼ TC, and continue thus until a sufficient number of points is obtained.

The length of curve can be conveniently found only by measurement on the ground.

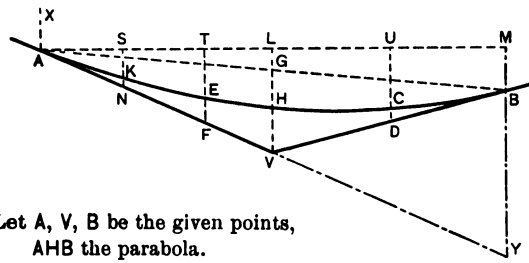
Note the difference in method between § 85 and § 133.

134. Vertical Curves.

It is convenient and customary to fix the grade line upon the profile as a succession of straight lines; also to mark the elevation above datum plane of each point where a change of grade occurs; also to mark the rates of grade in feet per station of 100 feet. At each change of grade a vertical angle is formed. To avoid a sudden change of direction it is customary to introduce a vertical curve at every such point where the angle is large enough to warrant it. The curve commonly used for this purpose is the parabola. A circle and a parabola would substantially coincide where used for vertical curves. The parabola effects the transition rather better theoretically than the circle, but its selection for the purpose is due principally to its greater simplicity of application. It is generally laid to extend an equal number of stations on each side of the vertex.

135. Problem. *Given the elevations above datum plane of grade line at the vertex, and at given points at equal distances each side of vertex, as P.C. and P.T.*

Required elevation of the vertical curve opposite the vertex; also at intermediate points.



Let A, V, B be the given points,
AHB the parabola.

Join AB; produce AV to Y.

Draw vertical lines AX, LGHV, MBY, and horizontal line ALM.

In the case of a vertical curve, the horizontal projections of AV and VB are equal, and AL = ML.

Therefore AG = GB, and AV = VY

VG is a diameter of the parabola.

AX is also a diameter.

$$HV = \frac{VG}{2}$$

$$\text{Elev. } H = \frac{1}{2}\left(\frac{\text{Elev. } A + \text{Elev. } B}{2} + \text{Elev. } V\right) \qquad (85)$$

The elevations of A, B, V, H, are all above "datum plane."

For intermediate points following § 131,

Let LU = UM.

$$\text{Elev. } C = \text{Elev. } D + \frac{HV}{4}$$

Let AS = ST = TL.

$$\text{Elev. } K = \text{Elev. } N + \frac{HV}{9}$$

$$\text{Elev. } E = \text{Elev. } F + \frac{4}{9}\,HV$$

136. Problem. *Given the rates of grade g of* AV ; *g′ of* VB; *the number of stations n, half on each side of vertex, covered by the vertical curve ; also the elevation of the point* A.

Required the elevation, at each station, of the parabola AB.

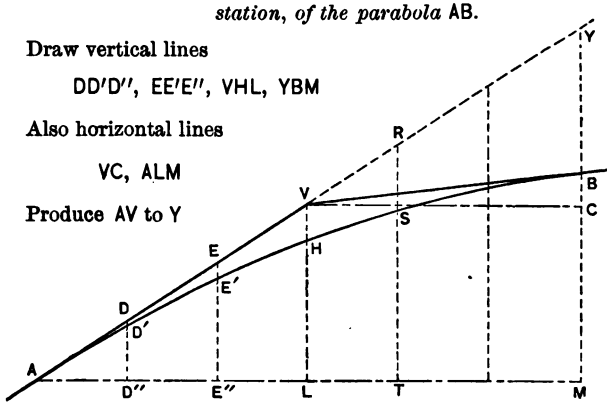
Draw vertical lines

DD′D″, EE′E″, VHL, YBM

Also horizontal lines

VC, ALM

Produce AV to Y



Let a_1 = offset DD′ at the first station from A.

a_2 = " EE′ " second " " A, etc.

Then $a_2 = 2^2 a_1 = 4\,a_1$

$a_3 = 3^2 a_1 = 9 a_1$

$a_n = n^2 a_1 = \text{YB}$

$\text{YB} = \text{YC} - \text{BC}$

$$n^2 a_1 = \frac{ng}{2} - \frac{ng'}{2}$$

$$a_1 = \frac{g - g'}{2\,n} \qquad (86)$$

Due regard must be given to the signs of both g and g' in these formulas, whether + or −.

From the elevation at A we may now find the required elevations, since we have given g

and we also have a_1

$a_2 = 4\,a_1$

$a_3 = 9\,a_1$ etc.

A method better and more convenient for use is given below.

$$DD'' = g; \quad D'D'' = g - a_1$$

$$EE'' = 2g; \quad E'E'' = 2g - a_2 = 2g - 4a_1$$

$$VL = 3g; \quad HL = 3g - a_3 = 3g - 9a_1$$

Again, $D'D'' = g - a_1 = g - a_1$

$$E'E'' - D'D'' = 2g - 4a_1 - (g - a_1) = g - 3a_1$$

$$HL - E'E'' = 3g - 9a_1 - (2g - 4a_1) = g - 5a_1$$

On a straight grade, the elevation of any station is found from the preceding, by adding a constant g.

On a vertical curve, the elevation of each station is found from the preceding by adding, in a similar way, not a constant, but a varying increment, being for the

1st station from A	$= g - a_1$	changing by successive
2d " " A	$= g - 3a_1$	differences of $2a_1$ in
3d " " A	$= g - 5a_1$	each case.

137. The Am. Ry. Eng. Assn. states as to length of vertical curves that "on Class *A* roads" (roads with large traffic) "rates of change of 0.10 per station on summits, and 0.05 per station in sags should not be exceeded. On minor roads 0.20 per station on summits, and 0.10 per station in sags may be used." With very steep grades, however, even higher rates than recommended by the Association may sometimes seem necessary.

The "rate of change per station" corresponds to $2a_1$ in the foregoing formulas.

Let r = rate of change per station.

Then from (86) $$r = \frac{g - g'}{n}$$

Also $$n = \frac{g - g'}{r} \qquad (87)$$

From practical considerations the vertical curve s general, extend an equal number of full stations on each the vertex.

Then *n must be an even number* (not odd)

$$n = \frac{g - g'}{r}$$

The rates of grade around the curve will be

$$g - \tfrac{1}{2}r; \quad g - 1\tfrac{1}{2}r; \quad g - 2\tfrac{1}{2}r, \text{ etc.}$$

Each rate differing by r from the preceding.

138. Example.

Given. Grades as follows:

Sta.	Elev.	Rate
5	117.00	
10	122.00	+ 1.00
15	124.00	+ 0.40

Then $n = 10\ (g - g')$
$= 10 \times 0.60$
$= 6$

$a_1 = \tfrac{1}{2}r = \frac{g - g'}{2n}$
$= \frac{0.60}{12}$
$= 0.05$
$r = 0.10$

Sta.	Elev.	
5	117.00	
	+ 1.00	$= g$
6	118.00	
	+ 1.00	$1.00 = g$
7	119.00	$- 0.05 = \tfrac{1}{2}$
	+ 0.95	$0.95 = g$
8	119.95	− 0.10
	+ 0.85	$0.85 \quad g$
9	120.80	− 0.10
	+ 0.75	$0.75 \quad g$
10	121.55	− 0.10
	+ 0.65	0.65
11	122.20	− 0.10
	+ 0.55	0.55
12	122.75	− 0.10
	+ 0.45	0.45
13	123.20	End of cur
	+ 0.40	$= g'$
14	123.60	
	+ 0.40	
15	124.00	

The elevation for Sta. 15 thus obtained agrees with th tion shown in the data. All the intermediate elevati therefore "checked."

CHAPTER VIII.

TURNOUTS.

139. A Turnout is a track leading from a main or other track.

Turnouts may be for several purposes.

I. *Branch Track* (for line used as a Branch Road for general traffic).

II. *Siding* (for passing trains at stations, storing cars, loading or unloading, and various purposes).

III. *Spur Track* (for purposes other than general traffic, as to a quarry or warehouse).

IV. *Cross Over* (for passing from one track to another, generally parallel).

The essential parts of a turnout are

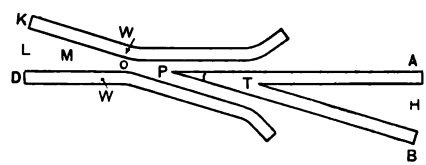
1. *The Switch.* 2. *The Frog.* 3. *The Guard Rail.*

1. Some device is necessary to cause a train to turn from the main track; this is called the "*Switch.*"

2. Again, it is necessary that one rail of the turnout track should cross one rail of the main track; and some device is necessary to allow the flange of the wheel to pass this crossing; this device is called a "*Frog.*"

3. Finally, if the flange of the wheel were allowed to bear against the point of the frog, there is danger that the wheel might accidentally be turned to the wrong side of the frog point. Therefore a *Guard Rail* is set opposite to the frog, and this prevents the flange from bearing against the frog point.

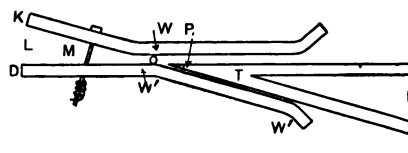
Frogs are of various forms and makes, but are mostly of this general shape, and the parts are named as follows: —



P = point
T = tongue
L = toe
H = heel
M = mouth
O = throat
WW = wings

This shows the "stiff" frog.

The "spring" frog is often used where the traffic on the main line is large, and on the turnout small. In the spring frog W′W′ is movable. AD represents the main line, and W′W′ is pushed aside by the wheels of a train passing over the turnout.

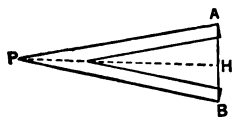


Frogs are made of certain standard proportions, and are classified by their number.

The "*Number*" n of a frog is found by dividing the length of the tongue by the width of the heel; $n = \frac{PH}{AB} = \frac{LH}{KD + AB}$.

The "*Frog angle*" is the angle between the sides of the tongue of the frog = APB.

140. Problem. *Given n. Required Frog Angle F.*



$$\cot \tfrac{1}{2} F = \frac{PH}{\tfrac{1}{2} AB}$$

$$\cot \tfrac{1}{2} F = 2n \qquad (89)$$

The frog is not brought to a fine "theoretical" point or edge; but is left blunt at the "actual" point; present practice leaves the frog one half inch thick at the actual point.

Let b = thickness at actual point.

Then nb = distance, theoretical to actual point of frog.

141. The form of switch commonly used at the present time is the "split switch." Fig. A shows the switch set for the turnout, and Fig. B for the main line. With the split switch the

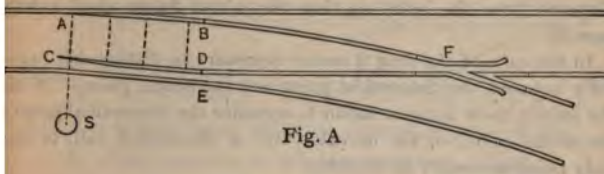


Fig. A

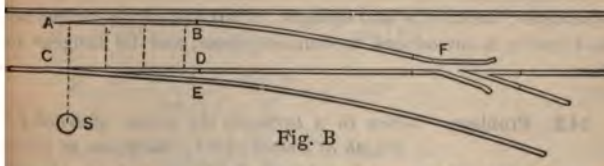


Fig. B

outer rail of the main line and the inner rail of the turnout curve are continuous. The switch rails, AB and CD, are each planed down at one end to a wedge point, so as to lie, for a portion of their length, close against the stock rail, and so guide the wheel in the direction intended. An angle, called the switch angle, is thus formed between the gauge lines of the stock rail and the switch rail, as DCE of Fig. B. The switch rails are connected by several tie rods, and one of the rods, near the point, is connected with another rod which goes to the switch stand S (or to a connection with the interlocking tower) from which the point of switch is thrown either for main track or for turnout as desired. The joint between the fixed end of the switch rail and the connecting rail, at B or D, is not bolted tight enough to prevent the slight motion of the switch rail necessary. The switch rail thus fastened at the end B is not spiked at all for its entire length, and acts as a hinged piece. Both rails thus move together, and through their entire length slide on flat steel plates provided for that purpose. The fixed (or hinged) end of this rail B is placed far enough from the stock rail to allow satisfactory spiking, frequently $5\frac{1}{2}$ or 6 inches. The length of switch rail varies from 11 feet to 33 feet in the standards of the American Railway Engineering Association.

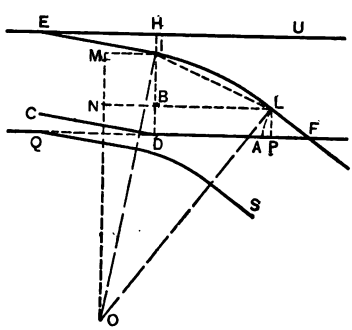
The switch rail is not planed to a fine edge but is left with appreciable thickness, frequently one quarter of an inch. The point is not left really blunt but is shaped down through a short distance from the point so that the wheel flange shall safely pass by.

In the case of the frog it seems necessary to distinguish carefully between the theoretical point and the actual point. With the switch there is no occasion to consider the theoretical point; the actual point, or the movable end of the switch rail, is the only point necessary to consider.

In laying out a turnout from a straight track, the switch rail is straight; the frog is also straight; a circular curve, called the lead curve, is introduced to connect these, and lie tangent to them.

142. Problem. *Given in a turnout, the gauge of track g; length of switch rail l; thickness at point w; heel distance between gauge sides of rails t; distance from theoretical point to toe of frog k; frog angle F and number n; thickness of frog at its point b.*

Required, radius of lead curve R; also lead E from point of switch to theoretical point of frog, and also to actual point of frog.



Let EILF and CDF be the rails of turnout,

EI and CD the switch rails.

ID is perpendicular to QDF.

Draw parallels and perpendiculars IM, LN, OM, LP, also arc LA.

Let S = switch angle HEI,

t = heel distance HI,

l = EI = QD = CD,

w = thickness of switch rail at E.

$$\sin S = \frac{t - w}{l}. \tag{90}$$

$$\mathsf{MN} = \mathsf{HD} - \mathsf{HI} - \mathsf{LP} = \mathsf{MO} - \mathsf{NO}$$

$$= g - t - k \sin F = \left(R + \frac{g}{2}\right) \cos S - \left(R + \frac{g}{2}\right) \cos F$$

$$R + \frac{g}{2} = \frac{g - t - k \sin F}{\cos S - \cos F} = \frac{g - t - k \sin F}{2 \sin \frac{1}{2}(F + S) \sin \frac{1}{2}(F - S)} \tag{91}$$

Let E_t = lead, point of switch to theoretical point of frog

E_a = lead, point of switch to actual point of frog

$$\mathsf{QF} = \mathsf{QD} + \mathsf{BL} + \mathsf{PF}$$

$$= \mathsf{QD} + \frac{\mathsf{IB}}{\tan \mathsf{ILB}} + \mathsf{LF} \cos \mathsf{LFP}$$

$$E_t = l + \frac{g - t - k \sin F}{\tan \frac{1}{2}(F + S)} + k \cos F \tag{92}$$

$$E_a = l + \frac{g - t - k \sin F}{\tan \frac{1}{2}(F + S)} + k \cos F + bn \tag{93}$$

143. *Given for the above turnout, F, S, g, k, E_a*
Required in the figure above, the closure DA *between heel of switch rail and toe of frog; also closure* IL *of curved rail.*

$$\mathsf{DA} = E_a - l - k - bn \tag{94}$$

$$\mathsf{IL} = \left(R + \frac{g}{2}\right) \text{angle } (F - S)$$

Since DA as computed is independent of R and IL is dependent upon R, any lack of precision in computing R will affect the difference between DA and IL, and I will not be exactly opposite D, as assumed.

The difference between IL and DA may be conveniently found with adequate precision as follows:

$$\mathsf{DA} = \mathsf{NL} - \mathsf{MI} - \mathsf{AP}$$

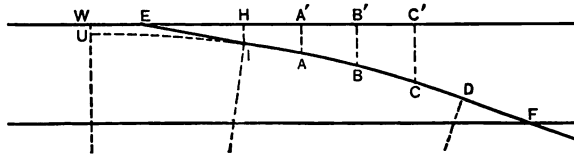
$$= \left(R + \frac{g}{2}\right) \sin F - \left(R + \frac{g}{2}\right) \sin S - k \text{ vers } F$$

$$\mathsf{IL} = \left(R + \frac{g}{2}\right) \text{angle } (F - S)$$

$$\mathsf{IL} - \mathsf{DA} = \left(R + \frac{g}{2}\right) [\text{angle } (F - S) - \sin F + \sin S] + k \text{ vers } F \tag{95}$$

Tot

144. *Given for a turnout, R, l, t, S.*
Required co-ordinates to curved rail at quarter points A, B, C.



Consider center of curve to be marked O.
Produce curve DI to U where it is parallel to EH.
Draw perpendiculars IH, AA′, BB′, CC′.

$$UW = t - \left(R + \frac{g}{2}\right) \text{vers } S = a \qquad (96)$$

$$EW = \left(R + \frac{g}{2}\right) \sin S - l = d \qquad (97)$$

$$IOD = F - S$$

$$UOA = S + \tfrac{1}{4}(F - S) \qquad UOB = UOA + \tfrac{1}{4}(F - S)$$

$$UOC = UOB + \tfrac{1}{4}(F - S) \qquad UOD = UOC + \tfrac{1}{4}(F - S) = F \text{ (for a check)}$$

$EH = l$ (without error of more than 0.01 foot)

$$EA' = \left(R + \frac{g}{2}\right) \sin UOA - d \qquad AA' = \left(R + \frac{g}{2}\right) \text{vers } UOA + a$$

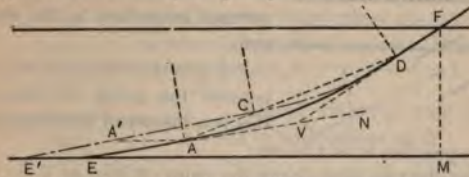
$$EB' = \left(R + \frac{g}{2}\right) \sin UOB - d \qquad BB' = \left(R + \frac{g}{2}\right) \text{vers } UOB + a$$

$$EC' = \left(R + \frac{g}{2}\right) \sin UOC - d \qquad CC' = \left(R + \frac{g}{2}\right) \text{vers } UOC + a$$

145. To avoid cutting rails, one or the other of the "closure" rails between heel of switch and toe of frog may be made full feet without fractions. By lengthening the tangent of the switch rail beyond the heel, the lead is increased; by lengthening the tangent of the frog back of the toe, the lead is decreased. The leads found in this way are called "practical leads"; the leads previously considered are called "theoretical leads."

The Am. Ry. Eng. Ass'n has adopted certain combinations of switches and frogs as "standard" and calculated a table of radii, leads (both theoretical and practical), and co-ordinates of quarter points. Table XXII A and XXII B show these.

Problem. *Given the increase of lead necessary to secure practical lead; also F, S, l, t, k, g.*
Required, increase of tangent past heel of switch.



Let EM = theoretical lead ; E′M = practical lead
EADF and E′A′CDF be the corresponding turnouts
EA = l ; E′C = l'

Draw parallel AA′; chords AD, CD ; tangents AVN, DV

Then E′E = given increase of lead ; A′C = required increase of tangent ; DVN = $F - S$

ADV = CDV = $\frac{1}{2}(F - S)$ and AC and AD coincide

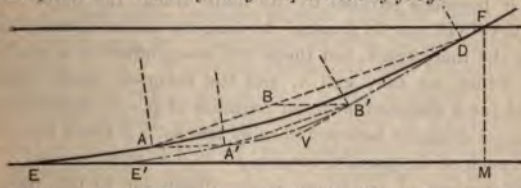
In triangle A′AC, A′CA = $\frac{1}{2}(F - S)$; CA′A = S ; A′A = E′E

$$A'C = \frac{E'E \sin \frac{1}{2}(F + S)}{\sin \frac{1}{2}(F - S)} = l' - l \qquad (98)$$

Following (91) $$R + \frac{g}{2} = \frac{g - t - (l' - l) \sin S - k \sin F}{2 \sin \frac{1}{2}(F + S) \sin \frac{1}{2}(F - S)} \qquad (99)$$

For finding co-ordinates of quarter points, use instead of (96) the following $$a = t + (l' - l) \sin S - \left(R + \frac{g}{2}\right) \text{vers } S \qquad (96\,A)$$

146. Problem. *Given the decrease of lead necessary to secure practical leads; also F, S, l, t, k, g.*
Required increase of tangent past toe of frog.

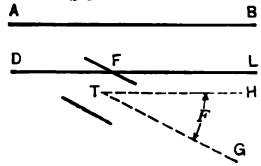


Let DF = k and B′F = k' From the figure it may be found that

$$B'D = \frac{E'E \sin \frac{1}{2}(F + S)}{\sin \frac{1}{2}(F - S)} = k' - k \qquad (100)$$

$$\frac{g - t - k' \sin F}{2 \sin \frac{1}{2}(F + S) \sin \frac{1}{2}(F - S)} = R + \frac{g}{2} \qquad (101)$$

147. It has become the custom to stake out the position of the frog point F. From this point F, a good track foreman will work backward and lay out the turnout according to the standard plan.



For any continuance of turnout beyond the point of frog, where this is a matter of fieldwork, a very common practice is as follows:

(*a*) Set the transit opposite the point of frog, at T.

(*b*) Lay off on the transit (on the proper side of 0°) the value of the frog angle *F*.

(*c*) Sight in the direction TH, parallel to AB.

(*d*) Turn off HTG = *F*.

(*e*) The transit then sights along TG with vernier at 0°.

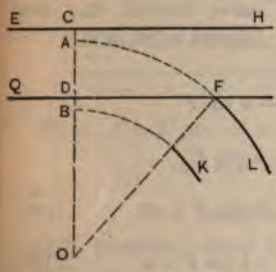
Any curve desired may then be laid off conveniently by deflection angles, and this curve will connect at T (opposite F) with whatever arrangement of track extends backward from the point of frog to the point of switch. Where the line in advance of F is new location, TG is the basis for that location; TG is either continued as a straight line, or it becomes the tangent to a desired curve and the transit is already set on TG with the vernier at 0°. When the turnout is to connect with some track parallel to the main track, the simplest method is to resolve the problem into a case of reversed curves with parallel tangents, by the following method, similar to that of § 125. If the curve used beyond F is extended backward toward the point of switch until it becomes parallel to the main track, the outer rail of this curve will not, in general, be tangent to the corresponding rail of the main track, but there will be an offset by a small distance which we may call a, and the reversed curve must be figured for a distance between parallels of $p - a$, rather than p, the actual distance between parallel tracks. If there be a turnout at each of the parallel tracks, $p - 2a$ should be used.

This method of treatment is not dissimilar to the use of p and q in spirals, and has value in many cases other than those of parallel tracks; several cases will be treated in the next chapter.

The method of finding a follows.

148. Problem. *Given a curve of radius R to be used beyond the frog; also F, n, g, b.*

Required the co-ordinates (from the frog point) of the point where the given curve produced backward becomes parallel to the main track.



Let LF be outer rail of given curve with center at O

EH, QF, rails of main track

Produce curve LF to A where it becomes parallel to EH, and draw OC perpendicular to EH

Let CA = a; FD = y

AD = x

To theoretical point of frog $y_t = \left(R + \frac{g}{2}\right) \sin F$ (102)

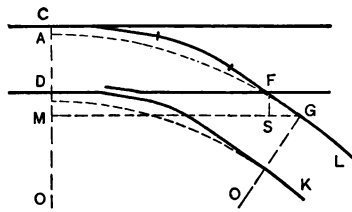
To actual point $y_a = \left(R + \frac{g}{2}\right) \sin F + nb$ (103)

$$x = \left(R + \frac{g}{2}\right) \text{vers } F \quad (104)$$

$$g - x = a = g - \left(R + \frac{g}{2}\right) \text{vers } F \quad (105)$$

If the curve produced backward becomes parallel above the rail ECH, the value of a becomes *minus* and where the problem is for a reversed curve between parallel lines the perpendicular distance used must be the distance between parallel lines $p + a$ rather than $p - a$. Where the curve to be used beyond the frog point has a large radius, the value of a will probably be *minus*.

With this method, the main track is used as a base-line and the point of frog the standard reference point; this corresponds with present good practice. If F be staked out on the ground or its position determined in the office, the position of point A is readily found by y, x, a. Conversely, if the position or station of A is found by computation, F is also determined. The entire split-switch turnout may then be laid out from F as a starting point and from QF or EH as reference lines.



149. If it be desired to use greater precision, and take into account the fact that the frog is straight from theoretical point F to heel G, and to make the curve beyond the frog tangent to FG at G,

Let FG $= h$

Then $\text{AD} = x = \left(R + \frac{g}{2}\right) \text{vers } F - h \sin F$

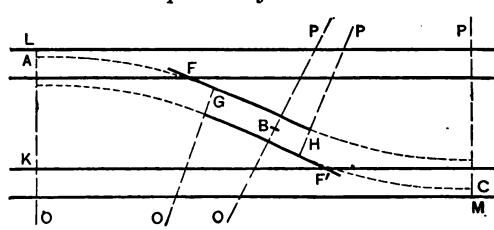
$\text{FD} = y_t = \left(R + \frac{g}{2}\right) \sin F - h \cos F$

$y_a = \left(R + \frac{g}{2}\right) \sin F - h \cos F + nb \qquad (106)$

$g - x = g - \left(R + \frac{g}{2}\right) \text{vers } F + h \sin F = a \qquad (107)$

150. Problem. *Given the radii R_1, R_2, of two parts of a reversed curve extending from heel of frog to heel of frog between parallel tracks; also unequal frog angles F, F'; also h, h', also perpendicular distance between tracks p, and gauge g.*

Required angles GOB *and* BPH.



Let G and H be heels of frogs F and F′

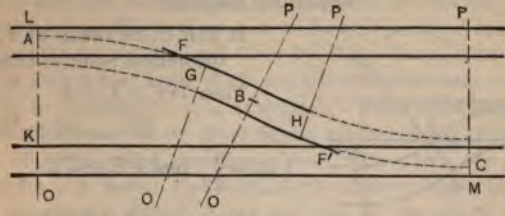
$\text{LK} = p$; $\text{OB} = R_1$; $\text{PB} = R_2$

Find $\text{LA} = a_1$ and $\text{MC} = a_2$ by (107)

From (76) $\text{vers AOB} = \dfrac{p - a_1 - a_2}{R_1 + R_2} \qquad (108)$

$\text{GOB} = \text{AOB} - F$ and $\text{BPH} = \text{AOB} - F'$

151. More commonly the two frogs will have the same number and the radii of the reversed curve will be the same.



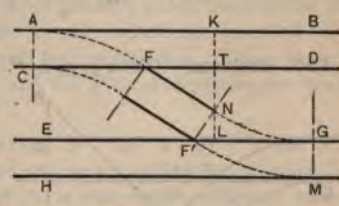
When $F = F'$ and $R_1 = R_2$

$$\text{vers AOB} = \frac{p - a - a}{R_1 + R_2} = \frac{\frac{1}{2}p - a}{R} \qquad (109)$$

$$\text{GOB} = \text{BPH} = \text{AOB} - F$$

152. Problem. *Given* $F = F'$, n, b; *also* p, g.

Required the length l, *of tangent between the two frogs.*



Let F and F′ be theoretical points of frogs

Draw KTNL perpendicular to AB

Then

$$\text{TN} = \text{KL} - \text{KT} - \text{NL}$$

$$\text{FN} \sin \text{TFN} = p - g - \text{F'N} \cos \text{F'NL}$$

$$l \sin F = p - g - g \cos F$$

$$l = \frac{p - g - g \cos F}{\sin F} \qquad (110)$$

l is the distance from the theoretical point at F to point N opposite the theoretical point at F′

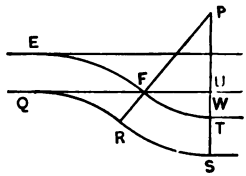
The above solution holds good whatever be the turnout used.

For a crossover between existing tracks, if the distance FF′ be calculated, both frog points can be located and the entire turnout staked out without transit.

from (30) $$\text{FF'} = l + \frac{g^2}{2\,l} \text{(approx.)}$$

The distance from actual point of one frog to the actual point of the other $= \text{FF'} - 2\,nb$.

153. Problem. *Given F, n, p, g.*
Required the radius of curve R_2, to connect the parallel tangents.



If *P.R.C.* be taken at F, the theoretical point of frog.

Then TPF $= I_r = F$

$$\text{UT} = \text{US} - \text{TS}$$

$$\left(R_2 - \frac{g}{2}\right) \text{vers } F = p - g$$

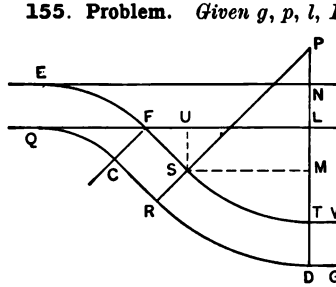
$$R_2 - \frac{g}{2} = \frac{p-g}{\text{vers } F}. \quad (111)$$

154. *Second Solution.* $\text{UT} = p - g$; $\text{PW} = R_2 - \frac{p}{2}$

by (118) $\text{PW} = \text{UT}\ 2\,n^2$

$$R_2 - \frac{p}{2} = (p-g)2\,n^2. \quad (112)$$

155. Problem. *Given g, p, l, F.*



Required R_2 of curve to connect parallel tangents.

Let F be the theoretical point of frog; l the distance from theoretical point of frog to S opposite *P.C.* of curve.

Draw the perpendiculars SU, SM.

Then $\text{SU} = \text{LM} = \text{NT} - \text{NL} - \text{MT}$

$\text{FS} \sin \text{UFS} = \text{NT} - \text{NL} - \text{PS vers SPT}$

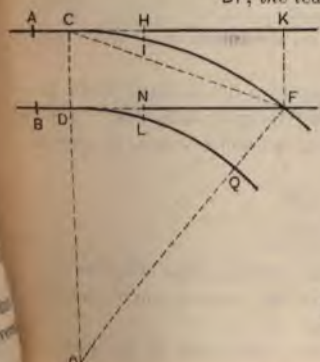
$$l \sin F = p - g - \left(R_2 - \frac{g}{2}\right) \text{vers } F$$

$$R_2 - \frac{g}{2} = \frac{p - g - l \sin F}{\text{vers } F} \quad (113)$$

By taking FS or $l = h$ (the distance from theoretical point to heel of frog) formula (113) covers the case where the reversing curve starts from the heel of frog.

156. A form of switch formerly in common use is the "*Stub-Switch*," which is formed by two rails, one on each side of the track, called the *Switch Rails*. One end of the rail for a short distance AC or BD (perhaps 5 or 10 feet) is securely spiked to the ties, the rest of the rail CI or DL being free to slide on the ties, so that it may meet the fixed rails of either main track at H or K, or turnout at I or L, as desired. These fixed rails, supported on a heavy tie or *Head Block*, are held by a casting, or piece of metal called the *Head Chair*, upon which the switch rail slides. A *Switch Rod* connects the ends of the switch rails with the *Switch Stand*. Since one end of the rail is spiked down, when the free end is drawn over by the switch rod the rail is sprung into a curve which may with slight error be considered a circular curve, tangent to the main line (if this be straight). In the stub-switch the outer rail of the turnout is assumed to be tangent both to the main track at C and to the frog at its point F. The distance through which the free end of the rail is drawn or *thrown* by the switch rod is called the *Throw* of the switch; this will be 5 or 6 inches. The free end of the rail is called the *Toe*, and the *P.C.* of the curve the *Heel* of the switch.

157. Problem. *Given gauge of track g; frog angle F; number of frog n; and throw of switch t. Required for a stub-switch, radius of turnout curve R; length of switch rail l; and* DF, *the lead E.*



Draw perpendicular FK

$$\text{COF} = F$$

$$\text{FO} = \frac{\text{CD}}{\text{vers COF}}$$

$$R + \frac{g}{2} = \frac{g}{\text{vers } F} \qquad (114)$$

$$\text{DF} = \text{OF} \sin \text{DOF}$$

$$E = \left(R + \frac{g}{2}\right) \sin F \qquad (115)$$

From (26) $t = \frac{l^2}{2R}$ (approx.)

$$l = \sqrt{2Rt} \qquad (116)$$

$$\mathrm{DF} = \mathrm{CD}\cot \mathrm{CFD}\,; \quad E = g\cot \tfrac{1}{2}F\,; \quad E = 2\,gn \qquad (117)$$

$$\mathrm{DF}^2 = \mathrm{FO}^2 - \mathrm{DO}^2$$

$$E^2 = \left(R + \frac{g}{2}\right)^2 - \left(R - \frac{g}{2}\right)^2$$

$$E^2 = \left(R + \frac{g}{2} + R - \frac{g}{2}\right)\left(R + \frac{g}{2} - R + \frac{g}{2}\right) = 2\,Rg$$

$$R = \frac{E^2}{2\,g} = \frac{(2\,gn)^2}{2\,g} = 2\,gn^2 \qquad (118)$$

$$R = En$$

$$l = \sqrt{2\,Rt} = \sqrt{4\,n^2gt} = 2\,n\sqrt{gt}$$

These formulas in § 156 and § 157 apply only in the case of the stub-switch, and are not to be used for split-switch turnouts.

158. Problem. *Given the degree D of a stub-switch turnout from a straight track.*

Required the degree of curve D' for a stub-switch turnout from a curved main track of degree D_m, F, n, g, remaining the same.

It may be shown that for a turnout to the inside of the curve

$$D' = D + D_m \text{ (approx.)} \qquad (119)$$

for a turnout outside the curve

$$D' = D - D_m \text{ (approx.)}$$

except that $D' = D_m - D$ (approx.)

when $D_m > D$

Take the case of the turnout on the inside of a curved main track.

When the main track is straight, g, the distance from frog point to the rail opposite, is the "tangent deflection" of § 70 for the outer rail of the turnout curve, whose degree is approximately D.

From (26 B) $a = a_1 D$

so that $g = a_1 D$

When the main line is curved, g becomes the offset between two curves, one the outer rail of the turnout curve, and the other the outer rail of main track.

Assuming the chords c for the outer rails of the turnout

curves to be equal in the two cases of straight main track and curved main track

by (27) $$a_{s-l} = a_1(D_s - D_l)$$

and the degree of the turnout curve must be such that

$$g = a_1(D' - D_m)$$

The values of c and E are nearly equal; so that what is true of the chord in this relation is also true of E (very closely). Therefore for a given value of E

$$D' = D + D_m \text{ (approx.)}$$

Furthermore the length of turnout curve is equal to c (very closely); for the given length $= c$ the angle $I = \frac{cD}{100} = F$, and since $D' - D_m = D$, the difference in angle $\frac{cD'}{100} - \frac{cD_m}{100} = \frac{cD}{100} = F$, so that the frog angle is not changed (materially).

Similar consideration of the two cases of turnout outside the curve of main track will show the expressions above to be true.

159. Example. Required the stub-switch turnout from a 3° main line curve using a No. 9 frog.

Table XXII shows for a No. 9 frog the

degree of curve	$=$	$7° 31' = D$
The degree of main line	$=$	$3° 00' = D_m$
degree of turnout	$=$	$10° 31' = D' = D + D_m$
By precise formula		$10° 32' = D'$

In a similar way for a turnout on the outside of the same curve

$$D' - D_m = D = 4° 31'$$

160. Another less mathematical, but very useful illustration is this: If we conceive the straight main track and the stub-switch turnout curve to be represented by a model where the rails are made of elastic material; using a "bending process" it will follow that if the main track rails be bent into a circular curve with the turnout inside, then the rails of the turnout curve will be bent into a sharper curve, and sharper by the degree of curve D_m into which the straight track is bent. Similarly when the straight track is bent in the opposite direction, the turnout curve will become flatter by the amount of D_m.

161. Problem. *Given F, n, k, g, R_m, D_m.*
Required the split-switch turnout from the given curved main track.

Tables XXII A and XXII B give, for various numbers of frog, the length of switch rail l, heel distance t, lead E, radius R and degree D of lead curve, length of frog from toe to theoretical point k; also co-ordinates to quarter points. These tables show the standards adopted by the Am. Ry. Eng. Assn. for turnouts from tangents.

For turnouts from curved tracks, applying the "bending process," l, t, k, E remain unchanged in length; this is true also of the co-ordinates at the quarter points, the y values being measured along the curved main rail and x values normal to this rail; straight rails become curved to the degree of the curved main track, track or rails already curved are bent into curves sharper than before by D_m (or flatter by D_m depending upon which side of the main track the curved track lies).

The degree of lead curve $D' = D \pm D_m$

The frog remains straight necessarily; the distance k is small for all sharp lead curves, and the resulting error will be small. Furthermore the straight frog is laid as part of the main track which is assumed to be curved, so that a correct mathematical treatment is impracticable.

The switch-rail can be and should be curved to the degree D_m. It is better to curve it in a bending machine, but it is often laid straight and the traffic depended upon to curve it to a fit against the stock rail.

162. Example. For a number 9 frog, Table XXII A gives

$$l = 16'\ 6''; \quad t = 6\tfrac{1}{4}''; \quad k = 6'; \quad h = 10'.$$

Table XXII B gives for "practical leads"

$$D = 9°\ 29'; \quad E_a = 72.28;$$

the co-ordinates are

28.75, 1.02; 40.98, 1.76; 53.19, 2.75

In using a number 9 turnout inside a 2° curved track

$$D' = 9°\ 29' + 2° = 11°\ 29'$$

The other linear dimensions remain unchanged.

163. Problem. *Given the radial distance p between a given curved main track and a parallel siding, also frog angle F (or number n), and gauge of track g.*

Required the radius R_2' of second curve to connect point of frog with siding.

I. When the siding is **outside** the main track.

Let CM be the inner rail of the given main line.

CFT inner rail of turnout.

R_m = radius of main line.

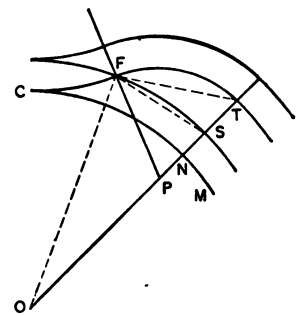
R_2' = radius of turnout.

p = TN = radial distance.

Connect FT, FO. Join FS.

Let FOT = O.

In triangle FTO,



$$\text{FO} = R_m + \frac{g}{2} \qquad \text{TO} = R_m - \frac{g}{2} + p$$

also $\text{OFT} + \text{OTF} = 180° - \text{FOT} = 180° - O$

$$\text{OFT} - \text{OTF} = \text{OFT} - \text{PFT} = F$$

tan $\frac{1}{2}(\text{OFT} + \text{OTF}) : \tan \frac{1}{2}(\text{OFT} - \text{OTF}) = \text{TO} + \text{FO} : \text{TO} - \text{FO}$

cot $\frac{1}{2} O$ $\quad : \tan \frac{1}{2} F = 2R_m + p : p - g$

$$\tan \tfrac{1}{2} O = \frac{p-g}{2R_m + p} \cot \tfrac{1}{2} F = \frac{p-g}{R_m + \frac{p}{2}} \cdot \frac{\cot \frac{1}{2} F}{2} = \frac{(p-g)n}{R_m + \frac{p}{2}} \quad (120)$$

Similarly $\qquad \text{FPT} = F + O$

In the triangle PFS, $\tan \frac{1}{2}(F+O) = \dfrac{(p-g)n}{R_2' - \frac{p}{2}}$;

$$R_2' - \frac{p}{2} = \frac{(p-g)n}{\tan \frac{1}{2}(F+O)} \quad (120) \qquad L = \frac{100\,(F+O)}{D_2'} \quad (121)$$

Since the main track is assumed to be curved past the frog and the frog is necessarily laid straight, it seems an unnecessary refinement to assume the frog straight from point to heel in this case.

164. Example.

Turnout from curve *outside* the main track.

Let $D_m = 4$; $n = 8$; $p = 15$; $g = 4.708$

Precise Method.

$$\tan \tfrac{1}{2} O = \frac{(p-g)n}{R_m + \frac{p}{2}} = \frac{10.292}{1440.2} \times 8 = \frac{82.336}{1440.2}$$

	82.336	log 1.915590
	1440.2	log 3.158422
$\frac{1}{2} O = 3° 16' 19''$		tan 8.757168
$\frac{1}{2} F = 3° 34' 30''$		
$\frac{1}{2}(F+O) = 6° 50' 49''$		tan 9.079448
	82.336	log 1.915590
	685.7	log 2.836142

$$R_2' - \frac{p}{2} = \frac{(p-g)n}{\tan \frac{1}{2}(F+O)} = \frac{82.336}{\tan 6° 50' 49''}$$

$\frac{1}{2} p = 7.5$

$R_2' = 693.2$

$D_2' = 8° 16'.4$

$$L = \frac{100\,(F+O)}{D_2'} = \frac{100 \times 13° 41' 38''}{8° 16'.4} = 165.5$$

Approximate Method.

Apply the "bending process" of p. 93.

In the case of a turnout from a straight main track, where $n = 8$ and $p = 15$,

from (112) $R_2 - \frac{p}{2} = (p-g)\,2\,n^2$

$= (15.0 - 4.708)\,2 \times 64 = 1317.4$

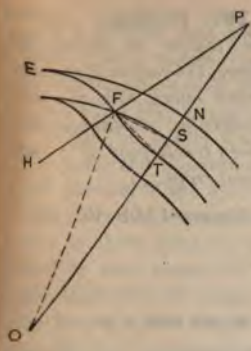
$R_2 = 1324.9$; $D_2 = 4° 19.5$; $F = 7° 09'$ (Table XXII.)

$L = \frac{100 \times 7° 09'}{4° 19.'5} = 165.3$ for straight tracks

$D_2' = D_2 + D_m$

$= 4° 19' + 4° = 8° 19'$ (8° 16' precise method)

$L = 165.3$ as with straight track (165.5 precise method).



165. II. When the siding is **inside** the main track.

In a similar fashion it may be shown, using this figure, that

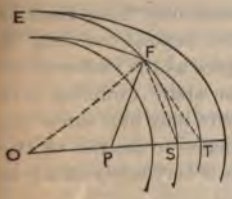
From triangle OFT

$$\tan \tfrac{1}{2} O = \frac{(p-g)n}{R_m - \frac{p}{2}} \qquad (122)$$

From triangle PFS

$$R_2' - \frac{p}{2} = \frac{(p-g)n}{\tan \frac{1}{2}(F-O)} \qquad (123)$$

$$L = \frac{100(F-O)}{D_2'} \qquad (124)$$



166. III. When the siding is **outside** the main track, but with the center of turnout curve inside of main track.

Let EFS be the outer rail of main track.

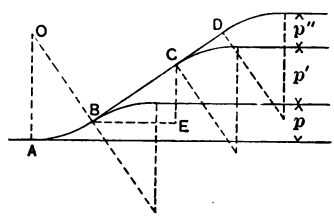
FT the inner rail of turnout.

From triangle OFT $$\tan \tfrac{1}{2} O = \frac{(p-g)n}{R_m + \frac{p}{2}} \qquad (125)$$

From triangle PFS $$R_2' - \frac{p}{2} = \frac{(p-g)n}{\tan \frac{1}{2}(F+O)} \qquad (126)$$

$$L = \frac{100(F+O)}{D_2'} \qquad (127)$$

With both § 165 and § 166, approximate results may be reached, by using the "bending method" of p. 93. Where the radius R_2 of the second curve is large and p is small, the approximate method will be sufficiently close; where p is large, the precise method will be necessary. Experience will determine in what cases it will be sufficient to use the approximate results, and where precise formulas should be used.



167. Problem. *Given for tracks as shown in figure, the radius R of stub-switch curve, also the perpendicular distances between tracks p, p', p''; also equal frogs.*

Required AOB, BC, CD.

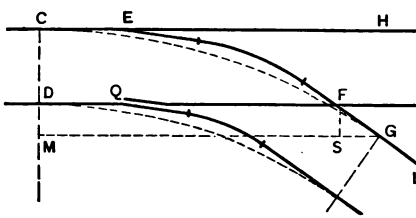
From (71) vers AOB $= \frac{\frac{1}{2}p}{R}$

also BC sin CBE = CE or BC sin AOB = p'

$$BC = \frac{p'}{\sin AOB}; \quad \text{and } CD = \frac{p''}{\sin AOB} \qquad (128)$$

Since the standard turnout curve extends only from heel of switch to toe of frog, any convenient curve beyond the frog is appropriate. If a curve of the same degree as the stub-switch curve be used beyond the frog point, the above formulas will apply (whatever the standard turnout curve may be), since the outer curved rail extended back comes tangent to the rail of the main track. The stub-switch curve thus is very convenient to use.

If it seems advisable to consider the frog straight from point at F to heel at G in the figure below,



Let FG = h

CM = $g + h \sin F$

$R = \frac{2}{3} n^2 (g + h \sin F)$

This is the radius of the curve whose outer rail is tangent to the rail of the main track and also to the frog at its heel G.

For a series of tracks like those above when the main track is curved, the computations may be made for straight tracks and the bending process applied. Just how far this process may be carried will be determined by experience.

In a freight yard the tracks on which cars are stored are called "body tracks" and the track which leads to and connects with, these body tracks is called the "ladder track." The track AD, § 167, is a ladder track.

When the ladder track leaves the main track in a straight line from the theoretical point of frog, if the body tracks are laid parallel to the main track, they may be laid out in straight lines from the theoretical point of the frogs used for the turnouts to these body tracks. With frogs of numbers commonly used in such cases, the distance BC or CD will be sufficient so that there will be plenty of room between the heel of frog and the point of the switch rail following it. For example, the parallel body tracks are seldom less than 12 ft. between centers; with a No. 8 frog and $p = 12$ ft. BC will be 96.4 ft.

The practical lead (Table XXII B) will be 68.0 ft.; from theoretical point to heel of frog will be (Table XXII A) 8.8 ft. Practical considerations involving bending the stock rail demand that the point of switch shall lie fully 4 ft. beyond the rail just at the heel of frog.

It is necessary, therefore, that on a ladder track the distance from the point of one switch to the point of the next switch shall not be less than $68.0 + 8.8 + 4.0 = 80.8$ ft. where a No. 8 frog is used. Since there is 96.4 ft. available and 80.8 ft. only needed, this arrangement of tracks leaves ample room.

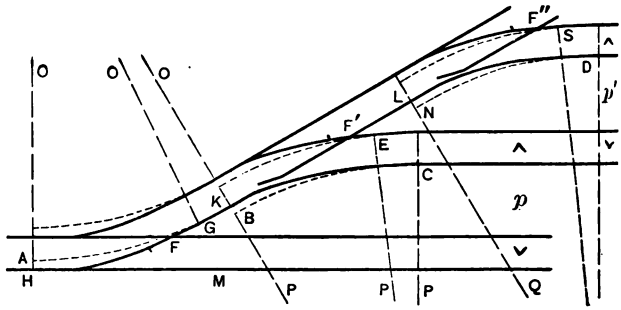
If the angle the ladder track makes with the main track be increased, the body tracks are lengthened and the ladder track becomes shorter; both of these results are of value. In the case taken above the angle can be increased until $\sin I = \frac{12}{80.8}$ or $I = 8° 32'$, or in general terms let q = clearance required from heel of frog to next point of next switch, then

$$\sin I \leq \frac{p}{E_t + h + q}$$

It will be necessary also that I shall not exceed the value of AOB in § 167.

The arrangement of a series of body tracks and the ladder tracks allows an opportunity, in many cases, for careful study and much ingenuity; an extended treatment here will not be justified.

168. Problem. *Given for tracks shown in figure the radius R of the curve beyond the heel of frog; also p, p' between parallel tracks; also F, n, g. Required angle* AOK *and distance* F'F''.



Let GK with its center at O be outer rail of the given curve of radius R.

Produce this curve to A when it is parallel to HM.

Let BC with center at P, and ND with center at Q, be similar curves produced.

Let FG, F'E, F''S be straight lines from theoretical point to heel of frogs.

$$OA = R + \frac{g}{2};\ BP = NQ = R - \frac{g}{2};\ AH = KB = LN = a$$

Find a by (107).

$$OP = R + \frac{g}{2} + a + R - \frac{g}{2} = 2R + a$$

Then by (76) $$\text{vers AOK} = \frac{p}{2R + a} \qquad (129)$$

by (128) $$KL = \frac{p'}{\sin AOK}$$

Since KF' = LF'' $$KL = F'F'' = \frac{p'}{\sin AOK} \qquad (130)$$

169. Problem. *Given the radial distance between a given curved main track and a parallel siding.*

The two tracks are to be connected by a cross-over, which shall be a reversed curve of given unequal radii beyond the frogs.

Required the central angle of each curve of the reversed curve.

Let AC = center line of inner track.

AO = R_m; RP = R_1'; RQ = R_2'

R_1' and R_2' are the radii of the curves beyond the frogs and may be assumed as any reasonable values.

Find a_1 and a_2 by applying the "bending process" (p. 93) and then (105) or (107).

Then in the triangle POQ find

$$PO = R_m + R_1' + a_1$$

$$PQ = R_1' + R_2'$$

$$OQ = OC + CB - BQ$$

$$= R_m + p \quad - R_2' - a_2$$

Solve for OPQ, PQO, POQ, then RQB

In practice this problem might take the following form:

Given R_m, p, g.

Assume n (or F) and n' (or F').

From these values of n and n' compute all data required for a cross-over between straight main tracks. This will involve assuming value of D_1 and D_2 and computing a_1 and a_2 by § 150 or § 151.

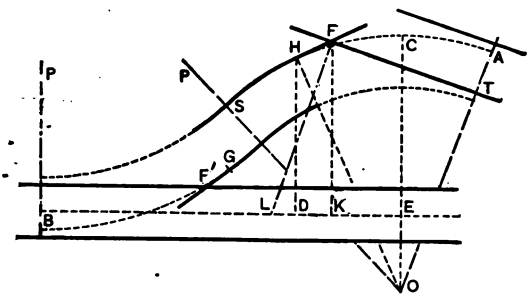
The values of a_1 and a_2 may be computed either for the case covered by (105) or by (107).

Then apply the bending process.

This will change the degrees of the turnout curves by the amount of D_m but the lengths of the turnout curves will remain unchanged (approx.) and the distances y_{a1} and y_{a2} obtained by (103) or (106) will also remain unchanged (approx.) as will also the values of a_1 and a_2.

170. Problem. *Given two main tracks not parallel. Al the unequal frog angles F, F' ; also n', h, h', g; also the unequal radii h R₂, of reversed curve connecting the t from heel to heel of frogs ; also the po tion of one frog* F.

Required the angles BPS *and* SOH *of the r versed curve ; also the position of point*



Let $OH = R_1 + \frac{g}{2}$; $BP = R_2 + \frac{g}{2}$

$HF = h$

Set transit at theoretical point of given frog F.

Lay off FL perpendicular to TF.

Measure FL, also FLE.

Draw perpendiculars HD, FK, OC.

Let I = angle between main tracks.

Then $FLE = 90° - LFK = 90° - I.$

$HOC = HOA - COA = F - I.$

$DK = h \cos (F - I)$

$FK = FL \cos I$; $LK = FL \sin I$

$HD = FK - h \sin (F - I)$

$$CE = HD + \left(R_1 + \frac{g}{2}\right) \text{vers } (F - I)$$

$$= FL \cos I - h \sin (F - I) + \left(R_1 + \frac{g}{2}\right) \text{vers } (F -$$

$$KE = \left(R_1 + \frac{g}{2}\right) \sin (F - I) - h \cos (F - I)$$

Find by (107) a_1 at A and a_2 at B.

Then $p = \mathrm{CE} - \frac{g}{2} - a_2$

$$\mathrm{OP} = R_1 + R_2$$

Solve by (76) for BPS and COS.

$$\mathrm{GPS} = \mathrm{BPS} - F' \; ; \; \mathrm{SOH} = \mathrm{COS} - (F - I)$$

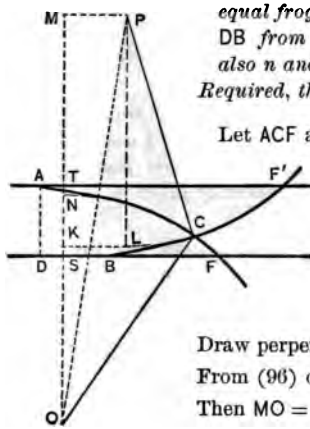
Also find $\mathrm{BE} = (R_1 + R_2) \sin \mathrm{BPS}$

$$\mathrm{LB} = \mathrm{BE} - \mathrm{KE} - \mathrm{LK}$$

From B, the point of frog F′ can readily be set in the field, its position having been established by (106) by computation.

171. Problem. *Given the R of either curve of a three-throw, or tandem split switch with switch rails of equal length; the equal frog angles F and F′; the distance* DB *from point to point of switch = d; also n and g.*

Required, the angle C of crotch frog at C.



Let ACF and BCF′ be rails of equal turnouts whose curves become parallel to DF at N and L.

Let $\mathrm{OC} = \mathrm{PC} = R + \frac{g}{2}$

Continue arcs to N and L; join PO.

Draw perpendiculars AD, OM, PM, KL, PL.

From (96) or (96 *A*) find $a = \mathrm{SK} = \mathrm{TN}$.

Then $\mathrm{MO} = \mathrm{MK} + \mathrm{NO} - \mathrm{NK}$

$$= R + \frac{g}{2} + R + \frac{g}{2} - (g - 2a)$$

$$\mathrm{MO} = 2R + 2a = 2(R + a)$$

$$\mathrm{MP} = \mathrm{KL} = \mathrm{DB} = d.$$

In right triangle OMP find MOP and PO.

In isosceles triangle PCO, $\cos \mathrm{COP} = \frac{\frac{1}{2}\mathrm{PO}}{\mathrm{OC}} = \frac{\frac{1}{2}\mathrm{PO}}{R + \frac{g}{2}}$ (131)

$$2\,\mathrm{COP} = C.$$

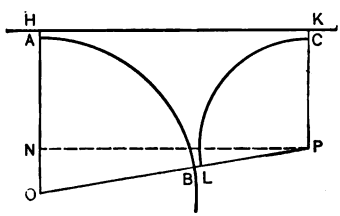
CHAPTER IX.

CONNECTING TRACKS AND CROSSINGS.

172. In many cases where a branch leaves a main track, an additional track is laid connecting the two. This is called a "*Y*" track, and the combination of tracks is called a "*Y*."

173. Problem. *Given a straight main track* HK, *also the P.C. and radius* R_1 *of curve beyond the frog. Also radius* R_2 *of "Y" track between the frogs. Also select practicable values of* F_1, F_2, F_3.

Required the distance HK *from P.C. of turnout to P.C. of "Y" track; also the central angles of turnout and of "Y" track to the point of junction.*



Let HK be the given straight main track.

AB the turnout.

CL the "*Y*" track.

Draw perpendicular NP.

Let $HK = NP = l$

$AOB = I_t$

$CPL = I_y = 180° - I_t$

Find $AH = a_1$; $KC = a_2$; $BL = a_3$ by (107) p. 88.

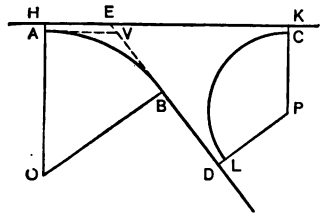
Then $\cos AOB = \frac{ON}{OP}$

$$\cos I_t = \frac{HO - KP}{OB + BL + LP} = \frac{R_1 + a_1 - R_2 - a_2}{R_1 + R_2 + a_3} \quad (132)$$

$$l = (R_1 + R_2 + a_3) \sin I_t \quad (133)$$

174. Problem. *Given a straight main track* HEK, *also the P.C., radius beyond the frog* OB, *and central angle* AOB, *of turnout curve connecting with a second tangent* BD; *also the radius* PC *of "Y" track. Also select practicable values of* F_1, F_2.

Required the distance HK *from P.C. of turnout to P.C. of "Y" track; also distance* BD *from P.T. of turnout curve to P.T. of "Y" track.*



Let HEK be the given main track; ABD the turnout; CL the "Y" track.

Let AO $= R_1$; CP $= R_2$
HK $=$ AC $= l$; BD $= m$
HA $= a_1$; KC $= a_2$
AOB $= I_1$; DL $= a_2$
CPL $= I_2$

Produce DB to E.

Draw parallel AV. Find a_1 and a_2 by (107).

$$\text{Then BD} = \text{ED} - (\text{VB} + \text{EV})$$

$$= \text{KP} \tan \tfrac{1}{2}\,\text{CPL} - \left(\text{AO} \tan \tfrac{1}{2}\,\text{AOB} + \frac{\text{HA}}{\sin \text{KEV}}\right)$$

$$= (R_2 + a_2)\tan \tfrac{1}{2} I_2 - \left(R_1 \tan \tfrac{1}{2} I_1 + \frac{a_1}{\sin I_1}\right)$$

$$m = (R_2 + a_2)\cot \tfrac{1}{2} I_1 - \left(R_1 \tan \tfrac{1}{2} I_1 + \frac{a_1}{\sin I_1}\right) \quad (134)$$

$$\text{also} \quad \text{HK} = \text{EK} + \text{EH}$$

$$l = (R_2 + a_2)\cot \tfrac{1}{2} I_1 + \left(R_1 \tan \tfrac{1}{2} I_1 - \frac{a_1}{\tan I_1}\right) \quad (135)$$

In case different frogs are used near D and K so that KC and DL are not equal, the formulas will be modified.

Let KC $= a_s$ the smaller value
DL $= a_l$ the larger value.

Following the method of § 191, p. 122:

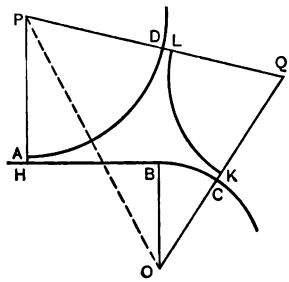
$$\text{EK} = (R_2 + a_s) \cot \tfrac{1}{2} I_1 + \frac{a_l - a_s}{\sin I_1}$$

$$\text{ED} = (R_2 + a_s) \cot \tfrac{1}{2} I_1 + \frac{a_l - a_s}{\tan I_1}.$$

175. Problem. In the accompanying sketch where

HBC = main track. AD = turnout.

LK = "*Y*" track.



Given HB = l; OB = R_m

AP = R_1; LQ = R_2.

Select F_1; F_2; F_3.

Required the points D and C.

Find AH = a_1; CK = a_2

DL = a_3 by (107)

then PH = $R_1 + a_1$

CQ = $R_2 + a_2$

DQ = $R_2 + a_3$

Considering PH + BO as base of a right triangle

HB as its altitude

Find OPH, and PO the hypotenuse

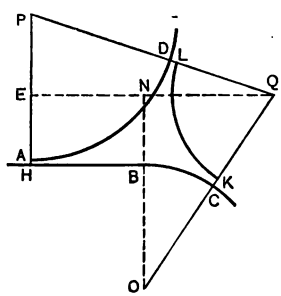
Find also PQ = $R_1 + R_2 + a_3$, QO = $R_m + R_2 + a_2$

then POQ, OPQ, PQO

then BOC, APQ

D and C will then be easily determined.

In the figure where HBC is the main track and LK is the turnout, AD the "*Y*" track.



Given OB = R_m; KQ = R_2

AP = R_1; BOC = O

Select F_1; F_2; F_3

Required the points A and D.

Find a_1, a_2, a_3 by (107)

Find QN, ON, then EP

also EQP, EQ

then EN = HB

and PQO = EQP + OQN

PQO determines position of L or D

EPQ determines length AD and EN = HB fixes H or A

In finding CK and DL in the foregoing problems of § 173 and § 175 the values of a_2 and a_3 are found from (107) after applying the "bending process."

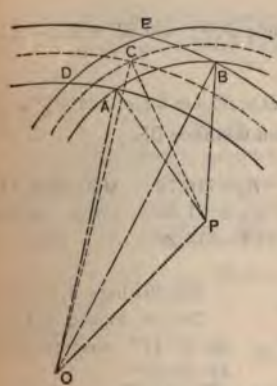
Example.

If curve AD is a 3° curve and Y track a 7° curve, then the offset $DL = a_3$ will be calculated just as it would be to connect a tangent with a 10° curve ($10° = 7° + 3°$), the same number or angle of frog being used.

Similarly the offset $CK = a_2$ will be the same as that for a tangent and a curve whose degree is the sum of the degrees of curves LK and BC.

176. Problem. *Given the radii,* R_1, R_2, *of two curves crossing at* C; *also the angle at crossing* C; *also* g *and* g'.

Required, the frog angles at A, B, D, E; *also the lengths on the curves of the rails* AB, BE, DE, AD.



Having given $OC = R_1$; $OCP = C$; and $PC = R_2$; find in triangle OCP, the line OP.

Having given $OA = R_1 - \frac{g}{2}$

also OP; and $PA = R_2 - \frac{g'}{2}$

find in triangle OPA, angles APO, AOP, and $OAP = A$.

Having given $OB = R_1 + \frac{g}{2}$

also OP; and $PB = R_2 - \frac{g'}{2}$

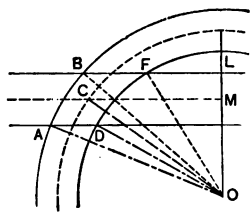
find in triangle OPB, angles BPO, BOP, and $OBP = B$.

Then $APB = BPO - APO$, and $AB = \left(R_2 - \frac{g'}{2}\right)$ angle APB.

The frog angles at D and E, and the lengths AD, DE, EB, may be calculated in similar fashion.

177. Problem. *Given a curve crossing a tangent, R, g, g', and angle C between tangent and curve.*
Required frog angles at A, B, F, D.

Draw AO, BO, CO, FO, DO; also, MO perpendicular to CM.



Then $\mathrm{MO} = R \cos C$

$$\cos \mathrm{MOA} = \cos A = \frac{\mathrm{MO} - \frac{g'}{2}}{R + \frac{g}{2}} \quad (136)$$

$$\cos \mathrm{MOD} = \cos D = \frac{\mathrm{MO} - \frac{g'}{2}}{R - \frac{g}{2}} \quad (137)$$

$$\cos B = \frac{\mathrm{MO} + \frac{g'}{2}}{R + \frac{g}{2}} \quad (138) \qquad \cos F = \frac{\mathrm{MO} + \frac{g'}{2}}{R - \frac{g}{2}} \quad (139)$$

$$\mathrm{DOF} = \mathrm{MOD} - \mathrm{MOF} = D - F$$

The rail length $\mathrm{DF} = \left(R - \frac{g}{2}\right)$ angle DOF; and $\mathrm{BF} = \mathrm{BL} - \mathrm{FL}$.

Example. *Given* $C = 32° 28'$; $D = 8°$ $g = 3$; $g' = 4' 8\frac{1}{2}''$.
Required angle D and distance DF.

R_8 log = 2.855385
32° 28′ cos = 9.926190
MO = 604.748 log = 2.781575
$\frac{1}{2} g'$ = 2.354
607.102 log = 2.783261
OF = 715.28 log = 2.854476
31° 55′ 23″ cos = 9.928785

Table XX. 42′ = 0.0122173
21″ = 0.0001018
0.0123191

R_8 = 716.78
$\frac{1}{2} g$ = 1.50
OD = OF = 715.28

MO = 604.748
$\frac{1}{2} g'$ = 2.354
602.394

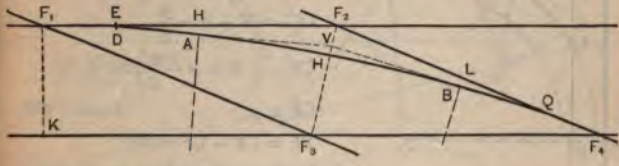
602.394 log = 2.779881
715.28 log = 2.854476
32° 37′ 44″ cos 9.925405
31° 55′ 23″
DOF = 0° 42′ 21″

2.854476 = log 715.28 = $R - \frac{g}{2}$
log = 8.090579
0.945055 log = 8.812 = DF.

178. When two tracks cross at a small angle, they are often connected by a "slip switch," in which the outer rail lies entirely within the limits of the crossing and is composed of two switch rails and a connecting curve as shown in the figure below.

Problem. *Given for a crossing of two tracks the angle of crossing frog F, also n, b, g; also clearance m from actual point of frog to point of split switch; also l and t.*

Required, lengths along rail between frog points; also radius R of curve for a slip switch.



Let $DA = QB = l$ = length of switch rail

$HA = LB = t$

$F_1E = F_4Q = m$ = clearance required

Then bn = distance between theoretical and actual points of frogs F_1 and F_4; in frogs F_2 and F_3 theoretical and actual points coincide.

$$F_1F_3 = \frac{g}{\sin F} + bn = F_1F_2 = F_3F_4 = F_2F_4$$

In the slip switch, produce the gauge lines DA and QB to V on the line F_2F_3. Although the point of switch has a thickness ED of about a quarter of an inch, no appreciable error results if DV be calculated assuming DF_2V to be a triangle, in which

$$F_2DV = S; \quad DF_2V = 90° - \frac{F}{2}; \quad F_2D = F_1F_2 - m$$

Then
$$AV = DV - l$$

$$R + \frac{g}{2} = \frac{AV}{\tan \frac{1}{2}(F - 2S)}$$

$$\text{Middle ordinate for chord AB} = \left(R + \frac{g}{2}\right) \text{vers } \tfrac{1}{2}(F - 2S)$$

$$\text{Arc AB} = \left(R + \frac{g}{2}\right) \text{angle } (F - 2S)$$

182. Problem. *Given a straight main track* IBC *and a curved branch track of radius* R_b *intersecting at an angle* I*; also radius* R_t *of turnout curve from heel of frog to branch line; also* F, n, h, b, g.
Required in the figure, IB, IOA

Fig. 1

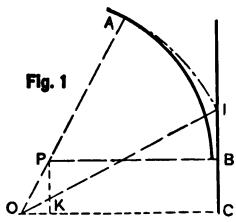
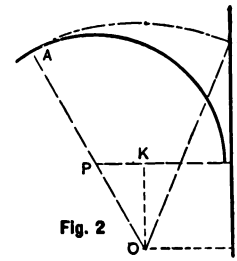


Fig. 2



Let O be the center of curve of branch line
P be the center of curve of turnout
Draw perpendiculars PB, OC, PK
Find a by (107)

$$\text{IOC} = I$$
$$\text{OC} = R_b \cos I;\ \text{IC} = R_b \sin I$$
$$\text{OP} = R_b - R_t$$

In Figure 1

$$\text{KO} = \text{OC} - (R_t + a)$$
$$\frac{\text{KO}}{\text{OP}} = \cos \text{POK};\quad \text{PK} = \text{OP} \sin \text{POK}$$
$$\text{IB} = \text{IC} - \text{PK};\quad \text{IOA} = \text{POK} - I$$

In Figure 2

$$\text{PK} = (R_t + a) - \text{OC}$$
$$\frac{\text{PK}}{\text{OP}} = \sin \text{POK};\quad \text{KO} = \text{OP} \cos \text{POK}$$
$$\text{IB} = \text{IC} - \text{KO};\ \text{IOA} = \text{POK} + 90° - I$$

Other cases will occur requiring figures different from those shown here · some of them will be suggested by the figures in 181.

183. Problem. *Given a straight track and a curved track of radius R_m intersecting at a given angle I; also radius R_t of turnout curve from heel of frog to heel of frog; also F, n, h, b, g. Required in the figure,* IOA, IB

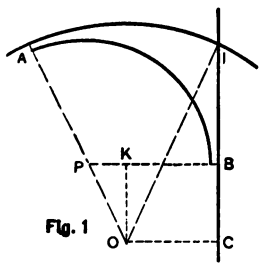


Fig. 1

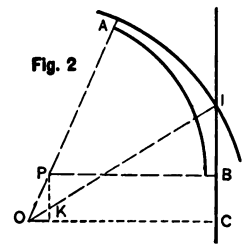


Fig. 2

Let O be the center of curve of main track
P be the center of curve of turnout
Draw perpendiculars PB, OC, OK, or PK
Find a_1 and a_2 at A and B by (107)

$$\text{IOC} = I$$
$$\text{OC} = R_m \cos I; \quad \text{IC} = R_m \sin I$$
$$\text{OP} = R_m - (R_t + a_1)$$

In Figure 1

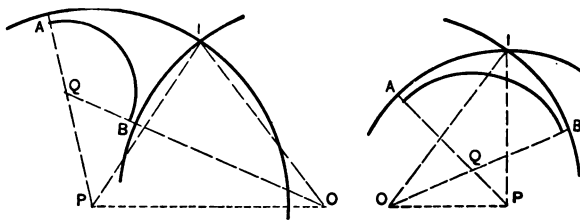
$$\text{PK} = R_t + a_2 - \text{OC}$$
$$\frac{\text{PK}}{\text{OP}} = \sin \text{POK}; \quad \text{KO} = \text{OP} \cos \text{POK}$$
$$\text{IB} = \text{IC} - \text{KO}; \quad \text{IOA} = \text{POK} + 90° - I$$

In Figure 2

$$\text{KO} = \text{OC} - (R_t + a_2)$$
$$\frac{\text{KO}}{\text{OP}} = \cos \text{POK}; \quad \text{PK} = \text{OP} \sin \text{POK}$$
$$\text{IB} = \text{IC} - \text{PK}; \quad \text{IOA} = \text{POK} - I$$

Other cases will occur requiring figures different from those shown here; some of them will be suggested by the figures in § 181.

184. Problem. *Given two curved lines of track of radii* R_1 R_2 *crossing each other, intersecting at an angle* I; *also the radius* R_t *of turnout from heel to heel of frog; also* F, n, h, b, g. *Required in the figure*, API, IOB



Let O and P be centers of main tracks
Q be center of turnout

$$OIP = I$$

Find a_1 at A, and a_2 at B by (107)
In triangle IOP,

$$IO = R_2;$$
$$IP = R_1;$$
$$OIP = I$$

Solve for OP, IOP, IPO
In triangle OQP,

$$QP = R_1 - (R_t + a_1)$$
$$QO = R_2 + (R_t + a_2)$$

OP computed
Solve for QOP, QPO, OQP
From QPO and IPO, find API
From IOP and QOP, find IOB

CHAPTER X.

SPIRAL EASEMENT CURVE.

185. Upon tangent, track ought properly to be level across; upon circular curves, the outer rail should be elevated in accordance with the formula

$$e = \frac{gv^2}{32.2\,R}$$

in which e = elevation in feet

g = gauge of track

v = velocity in feet per second

R = radius of curve in feet

In passing around a curve, the centrifugal force $c = \frac{Wv^2}{32.2\,R}$

It is desirable for railroad trains that the centrifugal force should be neutralized by an equal and opposite force, and for this purpose, the outer rail of track is elevated above the inner. Any pair of wheels, therefore, rests upon an incline, and the weight W resting on this incline may be resolved into two components, one perpendicular to the incline, the other parallel to the incline, and towards the center of the curve.

The component p parallel to the incline will be $p = \frac{We}{g}$

It will be a very close approximation to assume that c acts parallel to the incline (instead of horizontally). The centrifugal force will be balanced (approx.) if we make

$$p = c \text{ or } \frac{We}{g} = \frac{Wv^2}{32.2\,R}$$

whence

$$e = \frac{gv^2}{32.2\,R} \qquad (140)$$

In passing directly from tangent to circular curve, there is a point (at *P. C.*) where two requirements conflict; the track cannot be level across and at the same time have the outer rail elevated. It has been the custom to elevate the outer rail on the tangent for perhaps 100 feet back from the *P. C.* This is unsatisfactory. It has therefore become the best practice to introduce a curve of varying radius, in order to allow the train to pass gradually from the tangent to the circular curve.

186. The transition will be most satisfactorily accomplished when the elevation e increases uniformly with the distance l from the *T.S.* (point of spiral) where the spiral easement curve leaves the tangent; then $\frac{e}{l}$ is a constant

$$\text{or } \frac{gv^2}{32.2\,Rl} = A \text{ (a constant) or } Rl = \frac{gv^2}{32.2\,A}$$

Since g, v, A are constants, $Rl = C$ (a constant)

Then
$$Rl = R_c l_c \text{ and } R = \frac{R_c l_c}{l} \tag{141}$$

also
$$\frac{l}{D} = \frac{l_c}{D_c} \text{ or } \frac{D}{D_c} = \frac{l}{l_c} \tag{141 A}$$

where R_c = radius of circle

D_c = degree of circular curve

l_c = total length of spiral in feet.

Let s = the "Spiral Angle" or total inclination of curve to tangent at any point.

s_c = spiral angle where spiral joins circle.

Then
$$Rds = dl \text{ or } ds = \frac{dl}{R}$$

$$= \frac{l\,dl}{R_c l_c}$$

$$s = \frac{l^2}{2\,R_c l_c} \tag{142}$$

Again $dx = dl \sin s$ and $dy = dl \cos s$

All values of s will generally be small, and we may assume

$$\sin s = s \qquad \text{and} \qquad \cos s = 1$$

then $dx = s\,dl \qquad dy = dl$

$$= \frac{l^2\,dl}{2\,R_c l_c} = \frac{y^2\,dy}{2\,R_c l_c} \qquad y = l$$

Integrating, $$x = \frac{y^3}{6\,R_c l_c} \tag{143}$$

which is the equation of the "Cubic Parabola," a curve frequently used as an easement curve.

If, however, the approximation $\cos s = 1$ be not used, the resulting curve will be more nearly correct than is the Cubic Parabola. In this case $\sin s = s$

$$dx = s\,dl = \frac{l^2\,dl}{2\,R_c l_c}$$

Integrating, $$x = \frac{l^3}{6\,R_c l_c} \tag{144}$$

The resulting curve we may call, for the lack of a better name, the "Cubic Spiral" Easement Curve.

The Cubic Parabola is well adapted to laying out curves by "offsets from the tangent." Modern railroad practice favors "deflection angles" as the method of work wherever practicable. In the case of an easement curve the longitudinal measurements are most conveniently made as chords along the curve, so that $x = \frac{l^3}{6\,R_c l_c}$ represents a curve more convenient for use than is $x = \frac{y^3}{6\,Rl_c}$ as well as more nearly correct. Evidently the properties of the two curves will be very similar.

The following notation in connection with spirals has been adopted by the Am. Ry. Eng. Ass'n. For the point of change

from tangent to spiral, *T.S.*
from spiral to circular curve, *S.C.*
from circular curve to spiral, *C.S.*
from spiral to tangent, *S.T.*

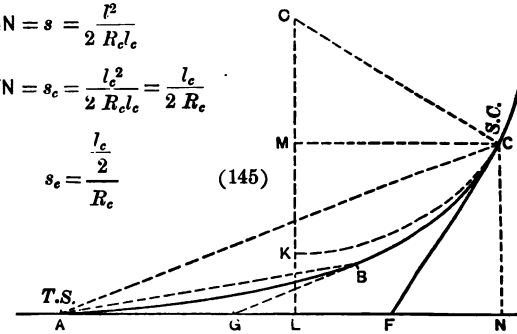
This notation will be adopted here.

187. *Given, in a Cubic Spiral, l, l_c, R_c*
Required s, s_c, and "total deflection angles" i, i_c

(142) BGN $= s = \dfrac{l^2}{2\,R_c l_c}$

and CFN $= s_c = \dfrac{l_c^2}{2\,R_c l_c} = \dfrac{l_c}{2\,R_c}$

$$s_c = \frac{\frac{l_c}{2}}{R_c} \qquad (145)$$



This (145) is the expression (in the form of length of arc for radius 1) for the central angle of the connecting circular curve for a length of one-half the length of spiral. In another form it is

$$s_c = \frac{l_c D_c}{200} \quad (l_c \text{ in feet and } s_c \text{ in degrees}) \qquad (145\,A)$$

If the circular curve be produced back from C to K where it becomes parallel to AN, its length in feet will be $\frac{l_c}{2}$ since KOC = CFN $= s_c$.

Also AL $= q = \dfrac{l_c}{2}$ (approx.) **(145 *B*)**

Again for any point B on the spiral

$$\sin \text{BAN} = \sin i = \frac{x}{l} \text{ (approx.)}$$

$$i = \frac{x}{l} \text{ (approx.)} = \frac{l^3}{6\,R_c l_c l} = \frac{l^2}{6\,R_c l_c}$$

But $s = \dfrac{l^2}{2\,R_c l_c}$ **from (142)**

Whence $i = \dfrac{s}{3}$ and $i_c = \dfrac{s_c}{3}$ **(146)**

Also $i : i_c = l^2 : l_c^2$; or $i = i_c \left(\dfrac{l}{l_c}\right)^2$ **(146 *A*)**

Also the back deflection ABG = BGN − BAN

$$= s - i = 3\,i - i = 2\,i$$

Also ACF $= 2\,i_c$ **(146 *B*)**

It will be observed that the Cubic Spiral has the following properties (some slightly approximate):

(*a*) The degree of curve varies directly with the length from the *T.S.* (141 *A*)

(*b*) The deflection angles vary as the squares of the lengths from the *T.S.* (146 *A*)

(*c*) The offsets from the tangent vary as the cubes of the lengths from the *T.S.* (144)

(*d*) The "spiral angle" at the point where the spiral joins the circular curve is equal to the central angle of a circular curve of the same degree and of a length one-half that of the spiral. (145)

(*e*) The deflection angle to any point on the spiral is one-third the spiral angle at that point. (146)

188. *Given* l, l_c, R_c. *Required* y *and* y_c.

From (30) the excess of hypotenuse over base

$$e = c - a = \frac{h^2}{2c}$$

Then in the Cubic Spiral, at any point on the spiral, let the excess $de = dl - dy$

from (30) $$de = \frac{dx^2}{2\,dl} = \frac{l^4\,dl^2}{2 \times 4\,R_c^2 l_c^2 dl} = \frac{l^4\,dl}{8\,R_c^2 l_c^2}$$

integrating, $$e = l - y = \frac{l^5}{40\,R_c^2 l_c^2}$$

$$y = l - \frac{l^5}{40\,R_c^2 l_c^2} \qquad (147)$$

$$y_c = l_c - \frac{l_c^5}{40\,R_c^2 l_c^2} = l_c - \frac{l_c^3}{40\,R_c^2} \qquad (147\,A)$$

189. *Given* R_c, y_c, x_c, s_c. *Required* $\mathsf{AL} = q$ and $\mathsf{LK} = p$.

$\mathsf{CN} = x_c$ and $\mathsf{AN} = y_c$

$\mathsf{AL} = \mathsf{AN} - \mathsf{OC} \sin \mathsf{COK}$ or $q = y_c - R_c \sin s_c$ (148)

$\mathsf{LK} = \mathsf{CN} - \mathsf{OC}$ vers COK $\quad p = x_c - R_c$ vers s_c (148 *A*)

Tables have been computed for the Cubic Spiral described above. These have been abandoned in favor of the spiral adopted by the Am Ry. Eng. Ass'n, and new tables arranged for this spiral which is described in the following section.

190. In the Cubic Spiral, the lengths have been considered as measured along the curve itself; but measurements in the field are necessarily taken by chords. This is recognized in defining the degree of a simple curve § 39 as the angle at the center subtended by a *chord* of 100 ft. Consistent with this, in the Am. Ry. Eng. Ass'n Spiral, the length of spiral is measured by *ten equal chords*, so that the theoretical curve is brought into harmony with field practice. This spiral will be referred to here as the A. R. E. A. Spiral, and adopted in place of the Cubic Spiral. The two curves substantially coincide up to the point where $s_c = 15°$, and the discussion of the Cubic Spiral applies in a general way to the A. R. E. A. Spiral also. Beyond $s_c = 15°$ the A. R. E. A. Spiral has its tables computed substantially without approximations, making it a very perfect and convenient transition curve even for sharp curves on street railways.

The A. R. E. A. Spiral retains the following features characteristic of the Cubic Spiral:

(*a*) The degree of curve varies directly with the length from the *T.S.*

$$\frac{D}{D_c} = \frac{l}{l_c} \qquad (141\,A)$$

(*b*) The deflection angles vary as the squares of the lengths from the *T.S.*

$$\frac{i}{i_c} = \left(\frac{l}{l_c}\right)^2 \qquad (146\,A)$$

(*d*) The spiral angle at the point where the spiral joins the circular curve is equal to the central angle of a circular curve of the same degree and of a length one-half that of the spiral.

$$s_c = \frac{l_c D_c}{200} \qquad (145\,A)$$

(*e*) For practical purposes the deflection angle to any point on the spiral is one-third the spiral angle at that point (up to a value of $s_c = 15°$),

or

$$i = \frac{s}{3} \qquad (146)$$

Beyond 15° and up to 45° for values of s_c, correct values have been computed by the Am. Ry. Eng. Ass'n and the following empirical formula is found to apply:

$$i = \frac{s}{3} - 0.00297\,s \text{ (seconds)}$$

With the A.R.E.A. Spiral, the angle made with the tangent at the *T.S.* by the first chord is taken as

$$\alpha_1 = \frac{s_c}{300}$$

No appreciable error is found to result if the angles made by successive chords with this tangent are taken as exact multiples of α_1 as follows:

1, 7, 19, 37, 61, 91, 127, 169, 217, 271

It is evident that these values of α_1, α_2, etc. depend upon s_c and are independent of the length of chord used.

For computing values of x_c, y_c the method of "offsets from the tangent" § 66 is adopted and co-ordinates x, y, at each chord point are found by using

$$\frac{l_c}{10}\sin\alpha_1,\ \frac{l_c}{10}\cos\alpha_1\ ;\ \frac{l_c}{10}\sin\alpha_2,\ \frac{l_c}{10}\cos\alpha_2, \text{ etc.}$$

For a given value of s_c the final co-ordinates $x_c y_c$ will be directly proportional to l_c, so that $\frac{x_c}{l_c} \cdot \frac{y_c}{l_c}$ will be constants of a given value of s_c. It will be true of the long chord C from *T.S.* to *S.C.* that $\frac{C}{l_c}$ will also be a constant.

A condensed table of values of $\frac{x_c}{l_c}$, $\frac{y_c}{l_c}$, $\frac{C}{l_c}$ is given in Table VII, B; for values of s_c differing by 0° 30′.

This table will have occasional rather than frequent use; intermediate values may be interpolated with sufficient precision for ordinary cases; the labor of interpolating will not be burdensome.

From these values of x_c and y_c, determined as above, values of i_c have been computed for successive values of s_c up to 45° and these are tabulated in Table VII. All of the computations mentioned above have been made by the Am. Ry. Eng. Ass'n.

For convenient use in the field the deflection angle to each chord point is necessary, and the author has computed these for successive values of s_c and tabulated them in Table VII.

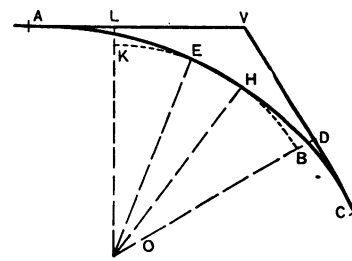
The deflection angles are constant for a given value of s_c and may be used for this value of s_c whatever the length of spiral, provided the chord length is made one-tenth the length of spiral.

Values of p and q have been computed by the author by (148) and (148 *A*) for various degrees of curve, and for various lengths of spiral, and these are found in Table VI which gives for each degree and half degree of curve, a series of lengths of spiral, and for each length, values of s_c, p, q, x_c, y_c, C.

191. Problem. *Given I, l_c, and R_c or D_c.*

Required the Tangent Distance T_s.

Find q and p by § 189 or by Table VI or by Table VII *B*.



(*a*) When the spirals at both ends of the circular curve are alike.

Let AL $= q$ and LK $= p$

$$\mathrm{AV} = \mathrm{AL} + \mathrm{LV}$$
$$= \mathrm{AL} + \mathrm{OL} \tan \tfrac{1}{2}\,\mathrm{LOD}$$
$$T_s = q + (R_c + p) \tan \tfrac{1}{2} I$$
$$T_s = q + T_c + p \tan \tfrac{1}{2} I \qquad (149)$$

where T_c is tangent distance for circular curve alone, for the given value of I.

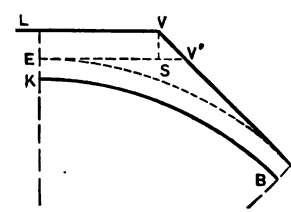
(*b*) When different spirals are used at the ends, separate values must be found for LV and DV.

Let $\mathrm{LK} = p_l$

$\mathrm{BD} = p_s$

Draw arc DE.

Also perpendiculars EV′, VS.



$$\mathrm{VS} = p_l - p_s$$

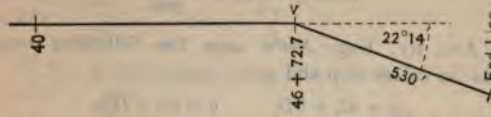
$$\mathrm{VV}' = \frac{p_l - p_s}{\sin I}$$

$$\mathrm{SV}' = \frac{p_l - p_s}{\tan I}$$

$$\mathrm{LV} = (R + p_s) \tan \tfrac{1}{2} I - \frac{p_l - p_s}{\tan I} \qquad (149\ A)$$

$$\mathrm{DV} = (R + p_s) \tan \tfrac{1}{2} I + \frac{p_l - p_s}{\sin I} \qquad (149\ B)$$

Example. *Given a line as shown in sketch.*
Required to connect the tangents by a 4° curve with a spiral 180 feet long at each end.



Find T_e Table III. $22° 14'$ $T_1 = 1125.8(4°$

281.45

Table IV. .05 corr.

Table VI. $p = 0.94$; $q = 89.97$ $281.50 = T_e$

nat tan $\frac{1}{2}(22° 14') = 0.19649$ $89.97 = q$

$0.19649 \times 0.94 = 0.18$ $.18 = p \tan \frac{1}{2} I$

$371.65 = T_s$

$s_e =$ $3° 36'$ $V = 46 + 72.7$

$2\ s_e =$ $7° 12'$ $3 + 71.7 = T_s$

$I =$ $22° 14'$ $T.S.\ 43 + 01.0$

$I - 2\ s_e =$ $15° 02'$ $1 + 80.0 = l_e$

$L = 4°)15.0333$ $S.C.\ 44 + 81.0$

375.8 $3 + 75.8 = L$

Table VI. $s_e = 3° 36' = 3°.6$ $C.S.\ 48 + 56.8$

Deflection angles for spiral from $1 + 80.0 = l_e$

Table VII. for $s_e = 3°.6$ $S.T.\ 50 + 36.8$

Transit at $43 + 01{,}0$ $T.S.$ Defl. angles for circular curve with transit at $44 + 81.0$

$i = 0° 01'$ to $43 + 19.0$ $s_e = 3° 36'$

$0° 03'$ $43 + 37.0$ $i_e = 1° 12'$

$0° 06'$ $43 + 55.0$ back deflection to $T.S.$ $= 2° 24'$

$0° 11'$ $43 + 73.0$

$0° 18'$ $43 + 91.0$ for $c_i = 19$, $\frac{d_i}{2} = 0° 23'$ 45

$0° 26'$ $44 + 09.0$ $2° 23'$ 46

$0° 35'$ $44 + 27.0$ $4° 23'$ 47

$0° 46'$ $44 + 45.0$ $6° 23'$ 48

$0° 58'$ $44 + 63.0$

$1° 12'$ $44 + 81.0$ for $c_f = 56.8$, $\frac{d_f}{2} = \frac{1° 08'}{7° 31'}$ $48 + 56.8$

$\frac{I - 2\ s_e}{2} = \frac{15° 02'}{2} = 7° 31'$ *Check*

192. Problem. *Given D_c and l_c.*
Required p, q, and other data for spiral

from (145 *A*) $$s_c = \frac{l_c D_c}{200}. \qquad (145\,A)$$

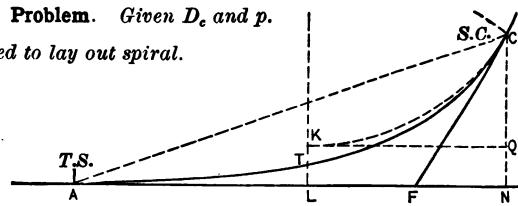
The Am. Ry. Eng. Ass'n uses the following empirical formulas for values of p and q,

$$p = al_c + bD_c \qquad q = el_c + fD_c.$$

Tables of the coefficients a, b, e, f, condensed from the A. R. E. A. Tables are given in Table VII *B* for values of s_c differing by 30′; intermediate values may be interpolated.

The deflection angles may be found as before from Table VII.

193. Problem. *Given D_c and p.*
Required to lay out spiral.



from (145) $$KC = \frac{l_c}{2} \text{ (approx.)},$$

from (145 *B*) $$q = \frac{l_c}{2} \text{ (approx.)}$$

$$CN = x_c = \frac{l_c^3}{6\,R_c l_c} = \frac{l_c^2}{6\,R_c} \qquad \text{for spiral}$$

from (26) $$CQ = \frac{c^2}{2\,R} = \frac{\left(\frac{l_c}{2}\right)^2}{2\,R_c} = \frac{l_c^2}{8\,R_c} \text{ (approx.)} \qquad \text{for circle}$$

therefore $$CN = \frac{4}{3}CQ = CQ + \frac{CQ}{3} = CQ + QN \text{ (approx.)}$$

$$CQ = 3\,QN = 3\,KL = 3p \text{ (approx.)}$$

$$CN = 4\,QN = 4\,KL \qquad \text{(approx.)}$$

from (144) $$\frac{x}{x_c} = \frac{l^3}{l_c^3} \qquad (149\,C)$$

$$CN = 2^3 TL = 8\,TL = 4\,KL$$

$$TL = \frac{KL}{2} = \frac{p}{2} \text{ (approx.)} \qquad (149\,D)$$

om CQ $= 3p$ the length of curve may be readily determined. the center of the circular curve KC be at O, then

$$\text{KOC} = \text{CFN} = s_e$$

rs $\text{KOC} = \frac{\text{CQ}}{\text{OK}}$ or vers $s_e = \frac{3p}{R_c}$

$\frac{100\, s_e}{D_c} = L$ for circular curve KC ; $l_e = 2L$

(146) $i_e = \frac{s_e}{3}$; for other deflections $i = i_e\left(\frac{l}{l_e}\right)^2$ (146 *A*)

ie back deflection ACF $= 2\, i_e$.

r the above method, the values of s_e and l_e may be reached substantial accuracy without the use of the spiral tables. ere close results are necessary, p may be re-computed by le VII *B* from the values of s_e and l_e already found by the ve formulas. If the new value of p is not sufficiently close ie given value, correct values of s_e and l_e may be found by . The value of q is found by Table VII *B*.

he deflection angles may then be taken from Table VII.

will be understood that the method of § 193 is more laborithan the more common method of § 191; its value lies in fact that it is thoroughly elastic and any given length of al may be used. In a similar way, if the value of p (together D_c) determines the spiral to be used, the method of § 193 mes useful.

pproximate Method.

oblem. *Given D_c and either l_e or p.*
Required s_e and the deflection angles without the use of tables.

sume the long chord KC to be equal to $\frac{l_e}{2}$.

$$R_1 = 5730 \qquad R_a = \frac{5730}{D_a}$$

§ 193 find $3p$ from R_c and L by (26) or find L from R_c $3p$ by (26)

$$L = q \text{ (approx.)}; \quad s_e = \frac{l_e D_e}{200}; \text{ and } i = \frac{s_e}{3}$$

her deflections are found by $i = i_e\left(\frac{l}{l_e}\right)^2$ (146 *A*)

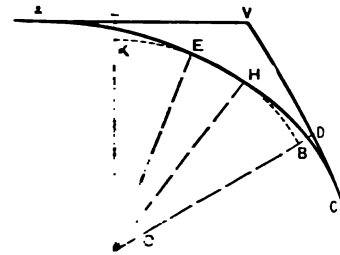
194. Fieldwork of Laying out Spiral.

1. Select on the ground the vertex V and measure I; or else fix on ground point $\perp$ opposite the point K where the circular curve will become parallel to tangent.

2. Select the length l_e of spiral to suit the given circular curve; this may be taken from Table VI or computed by § 193 from D, and I.

3. Find value of i_e and s_e from Table VI or by § 193.

4. Set $T.S.$ at A by measuring T_s from vertex, or by measuring l_e from point $\perp$ as the case may be.



5. With transit at $T.S.$ run in spiral using deflection angles from Table VII.

6. With transit at $S.C.$ turn vernier to 0° and beyond 0° to measure angle $s_e - \quad$; this will be $2\,i_e$ when s_e is less than 15°.

7. Take backsight on $T.S.$, and when vernier reads 0° the line of sight is on auxiliary tangent.

8. Run in circular curve by deflection angles; the central angle of circular curve $= I - 2\,s_e$.

With transit at $S.T.$ (set at $C.S.$) run in second spiral.

9. "Check" on $C.S.$

10. If the "check" is not substantially perfect, *re-set the point* $C.S.$

It is important that each spiral shall be correct throughout its entire length. In case the spiral and circular curve do not check properly at the $C.S.$, the discrepancy should be thrown into the circular curve where its effect will be unimportant.

When the circular curve is visible from the $C.S.$ the general method of § 91 will give the best results.

A. Lay out first spiral from $T.S.$ to $S.C.$

B. Lay out second spiral from $S.T.$ to $C.S.$

C. Set transit at $C.S.$ and lay out circular curve from $S.C.$ to $C.S.$ and check angle to $S.T.$

5. *Given D_c and l_c.*
Required to lay out spiral by offsets from the tangent.

om Table VI find value of x_c.
nd other values of x at convenient intervals by formula

$$x = x_c\left(\frac{l}{l_c}\right)^3 \qquad \text{(from 144)}$$

is method will be useful at times but more often spirals be laid out by deflection distances.

ample. *Given $D_c = 4°$, $l_c = 240$.*
Required offsets from tangent to spiral.

ke offsets at middle, quarter, and eighth points.
ble VI gives:

$l_c = 240$	$x_c = 6.70$
$l_4 = 120$	$x_4 = 6.70 \div 8 = 0.8375$
$l_2 = 60$	$x_2 = 0.8375 \div 8 = 0.1047$
$l_1 = 30$	$x_1 = 0.1047 \div 8 = 0.0131$
$l_3 = 90$	$x_3 = 0.0131 \times 3^3 = 0.35$
$l_5 = 150$	$x_5 = 0.0131 \times 5^3 = 1.64$
$l_6 = 180$	$x_6 = 0.0131 \times 6^3 = 2.83$
$l_7 = 210$	$x_7 = 0.0131 \times 7^3 = 4.49$

ıe "cubic spiral" will be laid out by measuring successive ds of 30 ft. each, and measuring the proper offset from the ent.

or the "Cubic Parabola,"

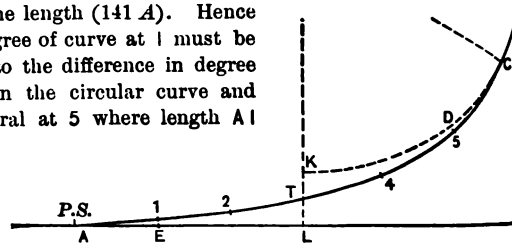
ormula is $$x = \frac{y^3}{6\,C}$$

ıce $$x = x_c\left(\frac{y}{y_c}\right)^3$$

e computations may be the same as for the cubic spiral. successive distances of 30 will be laid off on the tangent he offset laid off at right angles to the tangent.

196. It may occasionally (although not frequently) happen that the entire spiral cannot be laid out from the *T.S.*, and it will be necessary to determine deflection angles when the transit is at some intermediate point on the spiral. It will be desirable to occupy some regular chord point.

In any Cubic Spiral, the degree of curve *D* increases uniformly with the length (141 *A*). Hence the degree of curve at 1 must be equal to the difference in degree between the circular curve and the spiral at 5 where length A 1 = C 5.



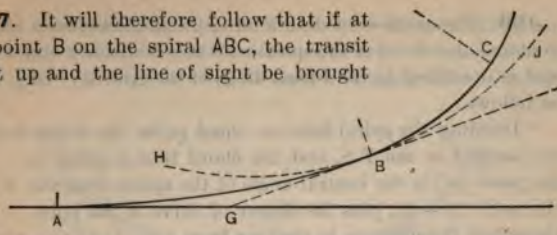
Since the divergence in the degree of the spiral is the same for a given distance, whether this divergence be from the tangent AL or from the curve CK, it will naturally follow from the principles established in § 69, that the offset to the spiral for a given distance from C will be the same as the offset for the same distance from A, since the change in degree at corresponding points is always the same whether from tangent or curve.

The same conclusion will be reached by referring to § 160 near the bottom of p. 93, where the elastic model and the "bending process" is referred to; this bending process being there found to be correct (approx.) from the demonstration § 158, p. 92. If this principle be correct, it will follow that KT = TL, which may be considered an extreme case. That KT = TL is demonstrated (in 149 *D*) to be correct is an additional assurance of the correctness of the principle stated above.

It will further follow if E 1 and D 5 are equal, and at equal distances from A and C respectively, that the angles E A 1 and D C 5 will be equal (closely). For the offset divided by the distance gives approximately the sine of the angle, and since the sines are equal, the angles also are equal; similarly the angles LAT and KCT are equal.

In other words, the divergence of any given spiral for a given distance, is the same either in offset or in angle, whether the divergence be from the tangent or from the circular curve.

197. It will therefore follow that if at ny point B on the spiral ABC, the transit e set up and the line of sight be brought



n the auxiliary tangent BG at that point, then the deflection ngle to any forward point on the spiral will be the sum of 1) the "total deflection angle," for the distance from B to at point, due to the circular curve HBJ, whose degree is the egree of the spiral at B; and (2) the "total deflection angle" rom the original tangent for that spiral for the same distance eckoned from the *T.S.* For any back point, the deflection ngle from this auxiliary tangent will be the difference between hese angles.

The proper use of these deflection angles will allow the line f sight to be brought on the auxiliary tangent, as well as give neans for setting all points on the spiral.

Example. Required forward deflection angles from point 6 n a spiral 300 feet long, to join 5° curve.

$$s_e = 7° 30' = 7°.5$$

The tangent BG is found by laying off from chord AB, twice he forward deflection to point 6, or $2 \times 54' = 1° 48'$.

D at point $6 = 0.6 \times 5°$		$= 3° 00'$
Deflection angle for 30 ft. on 3° curve		$= 27'$
The total angles will be at point	7, $27' + 01'$	$= 28'$
	8, $54' + 06'$	$= 1° 00'$
	9, $81' + 13'$	$= 1° 34'$
	10, $108' + 24'$	$= 2° 12'$
The back deflections will be at point	5, $27' - 01'$	$= 26'$
	4, $54' - 06'$	$= 48'$
	3, $81' - 13'$	$= 1° 08'$
	2, $108' - 24'$	$= 1° 24'$
	1, $135' - 37'$	$= 1° 38'$
	0, $162' - 54'$	$= 1° 48'$

The back deflection from point 6 to *T.S.* also $= 0° 54' \times 2 = 1° 48'$.

198. The method of determining the angle between the tangent and any chord of the spiral may now be readily understood, and is described in the Proceedings of the Am. Ry. Eng. Ass'n as follows:

"Dividing the spiral into ten equal parts, the angle between the tangent at the *T.S.* and the chord from a spiral $(n-1)$ to the point (n) is the central angle of the spiral from the *T.S.* to the point $(n-1)$, plus the degree of curve at the point $(n-1)$ times half the distance in stations from $(n-1)$ to (n), plus the deflection from the tangent at the *T.S.* to the chord subtending the first tenth of the spiral"

or
$$\alpha_n = \left(\frac{n-1}{10}\right)^2 s_c + \frac{n-1}{100} s_c + \frac{s_c}{300}$$

$$= \frac{3n^2 - 3n + 1}{100} s_c$$

"Substituting the successive numerals 1 to 10 for n, the successive values" of α "are 1, 7, 9, 19, 37, 61, 91, 127, 169, 217, and 271 — 300ths" of s_c.

In a similar fashion the Am. Ry. Eng. Ass'n has calculated the forward and backward deflections when the transit is at an intermediate station on the spiral and Table VII *A* shows these as multiples (by full numbers) of the first chord deflection angle i_1.

In finding the numbers for this Table the assumption was made that the deflection angle from the *T.S.* to any point is one third the spiral angle to that point, which is approximate only where s_c exceeds 15°. When the transit is set at a point P' and a deflection angle (from the auxiliary tangent at P') is taken to another point P'' the Am. Ry. Eng. Ass'n states:

"The formulas and rule are approximate and should not be used when the central angle from P' to P'' exceeds the central angle from the *T.S.* by more than 15°."

Table VII *A* furnishes a very simple method of finding forward and back deflections when it becomes necessary to set the transit at an intermediate point on the spiral. While multiplying i_1 may be somewhat burdensome, setting up at intermediate points will not be frequent, and simplicity is of prime importance.

199. Compound Curves. In the case of Compound Curves, it is proper and desirable that easement curves should be introduced between the two circular curves forming the compound curve.

Problem. *Given in a Compound Curve, D_l, D_s, p, or l.*
Required the Deflection Angles for a Cubic Spiral to connect the circular curves.

(*a*) Find by Table VII or by § **193** the Deflection Angles proper for a Cubic Spiral to connect a tangent with a circular curve of degree $= D_l - D_s$.

Let these $= i_1, i_2, i_3$, etc.

(*b*) Find the deflection angles to corresponding points on one of the circular curves, the auxiliary tangent for these being at the point where the Cubic Spiral leaves this circular curve (where the transit will be set).

Let these $= \frac{d_1}{2}, \frac{d_2}{2}, \frac{d_3}{2}$, etc.

(*c*) The required total deflections from A will be for

point 1 $\frac{d_1}{2} + i_1$ point 2 $\frac{d_2}{2} + i_2$

point 3 $\frac{d_3}{2} + i_3$ etc.

The required total deflections from C will be for

point 1 $\frac{d'_1}{2} - i_1$ point 2 $\frac{d'_2}{2} - i_2$ etc.

Similar procedure may be followed if it be desired to lay out the spiral by offsets. Convenient points may be set on the circular curves and the offsets taken from either curve.

Example. *Given* $D_1 = 4°$, $D_2 = 7°$, $l_c = 200$.

From Tables VI and VII find deflection angles for a cu
$D = 7° - 4° = 3°$ with $l_c = 200$, where $s_c = 3° 00'$. On 4°
lar curve deflection angle for 20′ chord = 0° 24′.

	4° curve deflection	+ spiral deflection	
for point 1	0° 24′	+ 0° 01′	= 0° 25′
2	0° 48′	+ 02′	= 0° 50′
3	1° 12′	+ 05′	= 1° 17′
4	1° 36′	+ 10′	= 1° 46′
5	2° 00′	+ 15′	= 2° 15′
6	2° 24′	+ 22′	= 2° 46′
7	2° 48′	+ 29′	= 3° 17′
8	3° 12′	+ 38′	= 3° 50′
9	3° 36	+ 49′	= 4° 25′
10	4° 00′	+ 60′	= 5° 00′

These are total deflection angles from auxiliary tangen
the transit is on the 4° curve.

Field work.

(*a*) Fix L or K in ground from topography or other pr
requirements, the same as for any compound curve.

(*b*) Assume l_c and compute p.

(*c*) Fix A and C, true transit points on curve at dista
from L or K.

(*d*) Set transit at A.

(*e*) Bring line of sight on auxiliary tangent at A.

(*f*) Set off "total deflection" angles to spiral and
spiral.

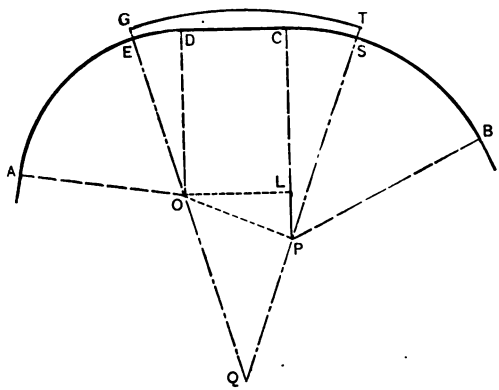
200. Determination of Length of Spiral.

The basis used by the Am. Ry. Eng. Ass'n for fixin
proper length of spiral is the increase per second of the
tion of the outer rail. Too rapid an increase, it is thought
cause some discomfort to passengers. The discussion is t
tended for a pocket book, and will not be attempted here.

The Am. Ry. Eng. Ass'n has prepared a diagram sho
Table VII *C* which covers the recommendation of the As
tion for fixing the length of spirals.

201. Problem. *Given two simple curves with connecting tangent.*

Required to substitute a simple curve of given radius with connecting spirals at each end.



Let DC $= t =$ given tangent, connecting the two curves AD and CB of radii R_s and R_l respectively.

Let GT be the given new curve of radius R_c.

Assume suitable spirals and find from table VI, GE $= p_1$ and ST $= p_2$ for these spirals, also q_1 and q_2.

Join OP and draw perpendicular OL.

Then $\tan \text{LOP} = \dfrac{R_l - R_s}{t}$; $\text{OP} = \dfrac{t}{\cos \text{LOP}}$

In the triangle OPQ there are given

$$\text{OP} = \frac{t}{\cos \text{LOP}};\ \text{OQ} = R_c - R_s - p_1;\ \text{QP} = R_c - R_l - p_2$$

Solve this triangle for OQP, QOP, OPQ.

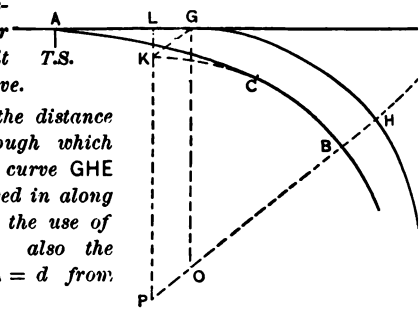
Then CPS $= 180° -$ (OPQ + OPL)

EOD $= 90° -$ (QOP + LOP)

Knowing the stations of D and C, the stations of E and S are readily found and also the stations of the *C.S.* and *S.C.* by applying q_1 and q_2.

202. Problem. *Given I and R_c for circular curve* GH *p and corresponding q for a spiral to fit the given curve.*

Required the distance BH = *h through which the circular curve* GHE *must be moved in along* VO *to allow the use of this spiral; also the distance* GA = *d from P.C. to T.S.*



$$\text{BH} = \text{PO} = \text{KG} = \frac{\text{KL}}{\cos \text{LKG}}$$

$$h = \frac{p}{\cos \frac{1}{2} I}$$

$$\text{GA} = \text{AL} + \text{LG}$$

$$= \text{AL} + \text{LK} \tan \text{LKG}$$

$$d = q + p \tan \tfrac{1}{2} I$$

Problem. *Given I, R_c and h.*
Required p and d.

$$p = h \cos \tfrac{1}{2} I$$

q is found by Table VII *B* or by §

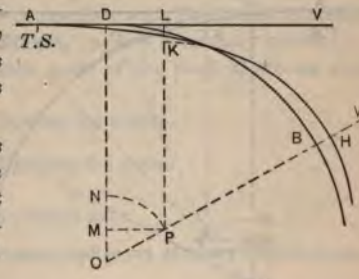
$$d = q + p \tan \tfrac{1}{2} I.$$

In re-running old lines to introduce spirals, where an circular curve is to be replaced by a spiral and a circul of the same degree, it is clear that the circular cur necessarily be set in towards the center from H by a amount h. Practical considerations may often fix the h by which the curve must be moved. The method will be found of considerable value in revisions of li it allows great flexibility in the selection of spirals.

203. It may sometimes seem more desirable to change the lius of the circular curve so as to keep the new alignment in :h position as to show as little deviation as possible from the alignment and at the same time keep the length of line as arly as possible unchanged. This may be accomplished as licated in the figure below, where the line is carried outwards B and inwards near D and L.

Problem. *Given I and R_1 for circular curve* DB; *also p spiral; also* BH $= h$ *asured along* VO *locat-* H *through which new cular curve is to pass allow the use of this iral.*

Required the radius $= R_2 =$ KP *of the new curve* H; *also q consistent ith p and R_2; also dis-nce* DA $= d$ *from P.C.* T.S.



$$\begin{aligned} \text{PO} = \text{NO} &= \text{OB} + \text{BH} - \text{PH} \\ &= R_1 + h - R_2 \\ \text{OM} &= \text{DO} - \text{DM} \\ &= \text{DO} - \text{PK} - \text{KL} \\ &= R_1 - R_2 - p \\ \text{NM} &= \text{NO} - \text{OM} = h + p \end{aligned}$$

$$\text{PO vers NOP} = \text{NM}$$

$$(R_1 - R_2 + h) \text{ vers } \tfrac{1}{2} I = h + p$$

$$R_1 - R_2 + h = \frac{h + p}{\text{vers } \frac{1}{2} I} \qquad (151)$$

Find q from p and R_2, by § **193**.

Then

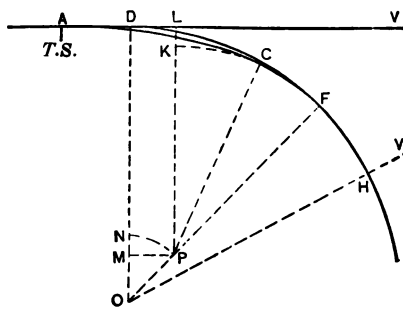
$$\begin{aligned} \text{DA} &= \text{AL} - \text{DL} \\ &= \text{AL} - \text{MP} \end{aligned}$$

$$d = q - (R_1 - R_2 + h) \sin \tfrac{1}{2} I. \quad (151$$

204. When it is necessary to keep the middle point H unchanged, on account of a bridge, or heavy embankment, or otherwise, it then becomes necessary to make part of the curve sharper, as CF in the figure below. The most practical method appears to be to assume the angle FOH, the part of the curve to remain unchanged; also assume the value of p and compute all other necessary data.

Problem. *Given I and R_1 of circular curve, also p of proposed spiral, also angle* FOH $= I_1$ *of the circular curve which is to remain unchanged.*

Required the radius R_2 of new curve CF, *to compound with original curve* FH; *also q consistent with p and R_2; also the distance* DA $= d$ *from P.C. to T.S.*



$$\text{FOH} = I_1$$

$$\text{DOH} = \tfrac{1}{2} I$$

$$\text{OP vers NOP} = \text{NM} = \text{MD} - \text{ND}$$

$$= \text{LP} - \text{KP} = p$$

$$(R_1 - R_2) \operatorname{vers} (\tfrac{1}{2} I - I_1) = p$$

$$R_1 - R_2 = \frac{p}{\operatorname{vers} (\frac{1}{2} I - I_1)} \qquad (152)$$

Find q from p and R_2 by § **193.**

Then

$$\text{DA} = \text{AL} - \text{DL}$$

$$= \text{AL} - \text{MP}$$

$$d = q - (R_1 - R_2) \sin (\tfrac{1}{2} I - I_1) \qquad (152A)$$

By making FOH $= I_1 = 0$, R_2 becomes continuous from the first spiral, through H and to its connection with the second spiral.

Another practical method would be to assume R_2 and p and compute I_1, q, d.

CHAPTER XI.

SETTING STAKES FOR EARTHWORK.

205. The first step in connection with Earthwork is staking out, or "**Setting Slope Stakes,**" as it is commonly called.

There are two important parts of the work of setting slope stakes:

I. Setting the stakes.

II. Keeping the notes.

The data for setting the stakes are:

(*a*) The ground with center stakes set at every station (sometimes oftener).

(*b*) A record of bench marks, and of elevations and rates of grades established.

(*c*) The base and side slopes of the cross-section for each class of material.

In practice, notes of alignment, a full profile, and various convenient data are commonly given in addition to the above.

206. I. **Setting the Stakes.** The work consists of:

(*a*) Marking upon the back of the center stakes the "cut" or "fill" in feet and tenths, as

C 2.3 or F 4.7.

(*b*) Setting side stakes or slope stakes at each side of the center line at the point where the side slope intersects the surface of the ground, and marking upon the inner side of the stake the "cut" or "fill" at that point.

207. (*a*) The process of finding the cut or fill at the center stake is as follows:

Given for any station the height of instrument $= h_i$, *and the elevation of grade* $= h_g$.

Then the required *rod reading for grade*

$$r_g = h_i - h_g. \tag{153}$$

It is not necessary to figure h_g for each station.

Let $h_{g_0} = h_g$ at Sta. 0

$h_{g_1} = h_g$ " " 1

$h_{g_2} = h_g$ " " 2, etc.

Also use similar notation for r_g.

Let g = rate of grade (rise per station)

Then $h_{g_1} = h_{g_0} + g$

$h_{g_2} = h_{g_1} + g$

$h_{g_3} = h_{g_2} + g$, etc.

$r_{g_0} = h_i - h_{g_0}$

$r_{g_1} = h_i - h_{g_1}$

$= h_i - (h_{g_0} + g) = h_i - h_{g_0} - g$

$$r_{g_1} = r_{g_0} - g \tag{154}$$

Similarly, $r_{g_2} = r_{g_1} - g$, etc.

It will be necessary, or certainly desirable, to figure h_g and r_g anew for each new h_i. It is well to figure h_g and r_g (as a check) for the last station before each turning point.

Example. $h_i = 106.25$

Sta. 0, grade elevation 100.00 rate $+1.00$
5, " " 105.00 " $+0.50$
10, " " 107.50

$r_{g_0} = 106.25 - 100.00 = 6.25$ 6.25

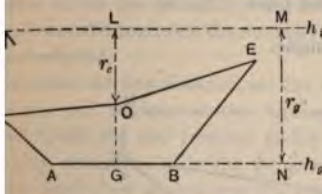
$r_{g_1} = 6.25 - 1.00 \left.\begin{matrix} \\ g \end{matrix}\right\} = 5.25$
$r_{g_2} = 5.25 - 1.00 = 4.25$
$r_{g_3} = 4.25 - 1.00 = 3.25$
$r_{g_4} = 3.25 - 1.00 = 2.25$
$r_{g_5} = 2.25 - 1.00 = 1.25$
Change in rate
$r_{g_6} = 1.25 - 0.50 = 0.75$
$r_{g_7} = 0.75 - 0.50 = 0.25$

is found necessary to take a *T.P.* here, and we therefore

$$h_{g_7} = h_{g_5} + 2g$$
$$= 105.00 + 1.00 = 106.00$$
$$r_{g_7} = h_i - h_{g_7} = 106.25 - 106.00 = 0.25$$

herefore all intermediate values r_{g_1}, r_{g_2}, etc., are "checked."

08. Having thus found r_g, next, by holding the rod upon surface of the ground at the center stake, the rod reading $r_c = LO$ is observed from the instrument. The cut or fill



$$c = OG = MN - LO$$
$$= r_g - r_c \quad (155)$$

In the figure given the values of r_g and c are posi-

; a positive value of c indicates a "cut," a negative value indicates a "fill."

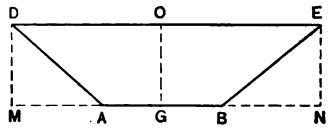
can be shown that in the two cases of "fill,"

1) When h_i is greater than h_g, and
2) When h_i is less than h_g,

formula given will hold good by paying due attention to the of r_g, whether $+$ or $-$.

209. (*b*) **Setting the Stake for the Side Slope.**

(1) *When the surface is level.*



Let $b = AB$ = base of section

$c = OG$ = center height

$s = \frac{BN}{EN} = \frac{AM}{DM}$ = side slope

$d = OD = OE$ = distance out

Then $d = GB + BN$

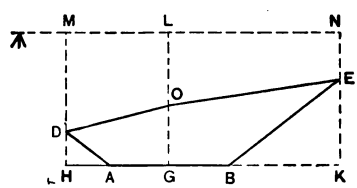
$= \frac{1}{2}b + s \times DM = \frac{1}{2}b + s \times EN$

$= \frac{1}{2}b + sc$

Setting the Stake for the Side Slope.

(2) *When the surface is not level.*

Here the process is less simple.



Let $b = AB$ = base

$c = OG$ = center height (or cut)

$s =$ slope

h_r = EK = side height right

h_l = DH = " " left

d_r = GK = distance out right

d_l = GH = " " left

Then
$$\left.\begin{aligned} d_r &= \tfrac{1}{2}b + sh_r \\ d_l &= \tfrac{1}{2}b + sh_l \end{aligned}\right\} \qquad (157)$$

But h_r and h_l are not known. It is evident from the figure that $h_r > c$ and $h_l < c$ in the case indicated, and therefore

$$d_r > \tfrac{1}{2}b + sc$$

$$d_l < \tfrac{1}{2}b + sc$$

It would be quite possible in many cases to take measurements such that the rate of slope of the lines OE and OD would be known, and the positions of E and D determined by calculation from such data. But speed and results finally correct are the essentials in this work, and these are best secured by finding h_l and h_r and the corresponding d_l and d_r upon the ground by a series of approximations, as described below.

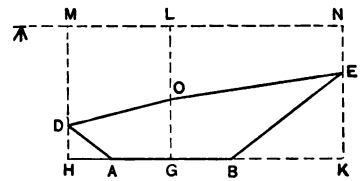
Having determined c, use this as a basis, and make an estimate at once as to the probable value of h_r at the point where the side slope will intersect the surface, and calculate $d_r = \frac{1}{2}b + sh_r$ to correspond.

Measure out this distance, set the rod at the point thus found, take the rod reading on the surface, and if the cut or fill thus found from the rod reading yields a value of d_r equal to that actually measured out, the point is correct. Otherwise make a new and close approximation from the better data just obtained, always starting with h_r and calculating d_r, and repeat the process until a point is reached where the cut or fill found from the rod reading yields a distance out equal to that taken on the ground. Then set the stake, and mark the cut or fill corresponding to h_r upon the inner side, as previously stated

Perform the same operation in a similar way to determine $d_l = \frac{1}{2}b + sh_l$, and mark this stake also upon the inner side with a cut or fill equal to h_l.

It requires a certain amount of work in the field to appreciate fully the process here outlined, but which in practice is very simple. It may impress some as being unscientific, and at first trial as slow, but with a little practice it is surprising how rapidly, almost by instinct, the proper point is reached, often within the required limits of precision at the first trial, while more than two trials will seldom be necessary, except in difficult country.

The instrumental work is just the same in principle as at the center stake.



Let $r_r = \mathrm{NE}$ = rod reading at slope stake right,

then $$\mathrm{KN} - \mathrm{NE} = r_g - r_r = h_r$$

here r_g is the same for center, right and left of section.

In some cases it may be necessary to make one or more resettings of the level in order to reach the side stakes from the center stake. In this case, of course, a new r_g must be calculated from the new h_t. This introduces no new principle, but makes the work slower.

A "slope-board" or "level-board" has quite frequently been used to advantage. In certain sections of country this might be considered almost indispensable. It consists simply of a long, straight-edge of wood (perhaps 15 ft. long) with a level mounted in the upper side. It is used with any self-reading rod. A rod quickly hand marked will serve the purpose well. Having given the cut or fill at the center, or at any point in the section, the leveling for the side stakes, and for any additional points, can readily, and with sufficient accuracy, be done by this "level-board," and the necessity for taking new turning points and resetting the level avoided.

LO. II. *Keeping the Notes.*

The form of note-book used for keeping the notes of slope stakes and of center cuts and fills, often called "cross-section" notes, is shown on the following two pages.

The left-hand column for stations should read from bottom to top.

The surface elevations in column 2 are *not obtained directly from the levels*, but result from adding to the grade elevation at any station the cut or fill at that station, paying due attention to the signs. This column of surface elevations need not be entered up in the field, but may be filled in as office work more economically.

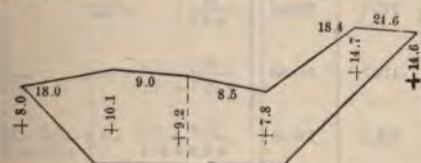
The column of grade elevations consists of the grade elevations as figured for each station.

The figures marked + are cuts in feet and tenths, and those marked − are fills; the figures above the cuts and fills are the distances out from the center, and the position in the notes, whether right or left of the center, corresponds to that on the ground.

The columns on the right-hand page are used for entering, when computed, the "quantities," or number of cubic yards, in each section of earthwork.

The column "**General Notes**" is used for entering extra measurements (of ditches, etc.) not included in the regular cross-section notes; also notes of material "hauled"; classification of material and various other matters naturally classed under the head of "Remarks."

When the surface is irregular between the center and side stakes, additional rod readings and distances out are taken, and the results entered as shown for station 0 on p. 144, the section itself being as shown below in the sketch.



Station 0

211. Form of Cross-Section Book (left-hand page).

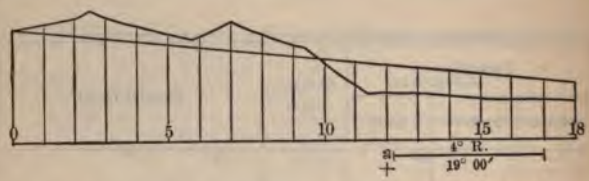
(Date)
(Names of Party)
Base 20; 1 to 1
14; 1½ to 1

Station	Surface Elev.	Grade Elev.	Cross-Section		
5	97.1	105.00	$\frac{18.4}{-7.6}$	−7.9	$\frac{16}{-}$
+69.7 *P.T.*	94.4	104.70	$\frac{22.1}{-10.1}$	−10.3	$\frac{2}{-1}$
4	96.9	104.00	$\frac{19.3}{-8.2}$	−7.1	$\frac{1}{-}$
+27.2 *P.C.*	98.0	103.27	$\frac{16.6}{-6.4}$	−5.3	$\frac{1}{-}$
3	98.1	103.00	$\frac{16.0}{-6.0}$	−4.9	$\frac{1}{-}$
+87	100.6	102.87	$\frac{13.3}{-4.2}$	−2.3	
+76	102.8	102.76	$\frac{10.3}{-2.2}$	0.0	$\frac{-}{+}$
+64	103.7	102.64	$\frac{10.0}{0.0}$	+1.1	$\frac{-}{+}$
+50	106.4	102.50	$\frac{13.4}{+3.4}$	+3.9	$\frac{-}{+}$
2	115.1	102.00	$\frac{16.7}{+6.7}$	+13.1	$\frac{-}{+}$
1	117.7	101.00	$\frac{22.7}{+12.7}$ $\frac{10.0}{+17.2}$	+16.7	$\frac{10.0}{+13.1}$ $\frac{-}{+}$
0	109.2	100.00	$\frac{18.0}{+8.0}$ $\frac{9.0}{+10.1}$	+9.2	$\frac{8.5}{+7.8}$ $\frac{18.4}{+14.7}$ $\frac{-}{+}$

:. **(Right-hand Page.)**

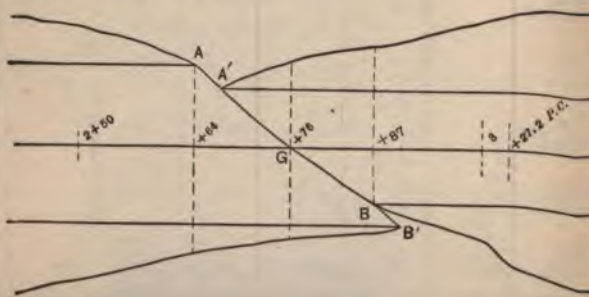
Excavation			Embank-ment	General Notes
›ck	S. Rock	Earth		

213. Cross-sections are taken at every full station, at every *P. C.* or *P. T.* of curve, wherever grade cuts the surface, and in addition, at every break in the surface. In the figure below, showing a profile, sections should be taken at the following stations: —



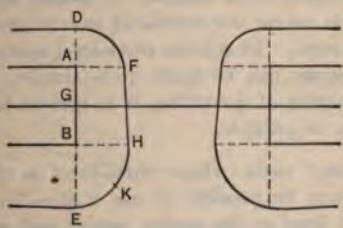
At Stations 0, 1, 2, 2 + 52, 3, 4, 5, 5 + 80, 6, 7, 8, 9, 9 + 29, 9 + 82, 10, 11, 11 + 30, 12, 12 + 25 *P. C.*, 13, 14, 15, 16, 17 *P. T.*, 18.

214. It is not necessary actually to drive stakes in *all* cases where a cross-section is taken and recorded, but in every case where they will aid materially in construction stakes should be set. It is best to err on the safe side, which is the liberal side. In passing from cut to fill, it is customary to take full cross-sections, not only at the point where the grade line cuts the surface at the *center* line of survey, but also where the grade cuts the surface at the outside of the base, both *right* and *left*, as in the figure below, which illustrates the notes on p. 144. Full cross-sections are taken not only at stations 2 + 76, but also at 2 + 64 and 2 + 87.



215. Stakes are actually set at the center G and at the point A, where the outside line of the base of *Excavation* cuts the surface, and at B, where the outside line of the base of *Embankment* cuts the surface. It is not customary to set stakes or record the notes for the points A′ and B′. The stakes at A, G, and B are a sufficient guide for construction, and the solidities or "quantities" would in general be affected only slightly by the additional notes if they were made. When the line AGB crosses the center line nearly at right angles, it would not be necessary to take more than one section so far as the notes are concerned. It is well, however, to set the stakes A and B exactly in their proper position.

216. Wherever an opening is to be left in an Embankment for a bridge or for any other structure, stakes should be set as in the figure below: —



At A and B (at the side of the base and top of the slopes AF and BH) stakes should be set marked "*Bank to Grade*"; and at F and H (at the foot of the slopes) stakes should be set marked "*Toe of Slope.*" Where the bank is high, an additional stake K at foot of slope may be set as an aid to construction. The stakes at D and E should also be set as ordinary slope stakes.

217. The "level notes" proper, or the record of heights of instrument, bench marks, turning points, etc., used in setting slope stakes, are usually kept separate from the cross-section notes. One reason for this is that level notes run from top to bottom of page, while cross-section notes read from bottom to top of page. The level notes should be kept either in the back

of the cross-section book or in a level book carried for that purpose. Keeping these or any other notes on a slip of paper is bad practice.

218. Earthwork can be most readily computed when the section is a "*Level Section*," that is when the surface is level across the section; but this is seldom the case, and for purposes of final computation it is not often attempted to take measurements upon that basis.

219. In general, in railroad work, the ground is sufficiently regular to allow of "*Three-Level Sections*" being taken, one level (elevation) at the center and one at each slope stake, as shown by these notes, where Base is 20, and Slope $\frac{1}{2}$ to 1:—

$$\frac{11.3}{+2.6} \qquad +4.2 \qquad \frac{12.8}{+5.5}$$

The term "*Three-Level Section*" is usually applied only to *regular* sections where the widths of base on each side of the center are the same. In regular three-level sections the calculation of quantities can be made quite simple. To facilitate the final estimation of quantities, it is best to use three-level sections as far as possible.

220. In many cases where three-level sections are not sufficient, it may be possible to use "*Five-Level Sections*," consisting of a level at the center, one at each side where the *base* meets the side slope, and one at each side slope stake, as shown by the following notes:—

Base 20, Slope 1 to 1,

$$\frac{22.7}{+12.7} \qquad \frac{10.0}{+17.2} \qquad +16.7 \qquad \frac{10.0}{+13.1} \qquad \frac{22.2}{+12.2}$$

The term "*Five-Level Section*" is usually applied only to regular sections where the base and the side slopes are the same on each side of the center.

221. Where the ground is very rough, levels have to be taken wherever the ground requires, and the calculations must be made to suit the requirements of each special case, although certain systematic methods are generally applicable. Such sections are called "*Irregular Sections*."

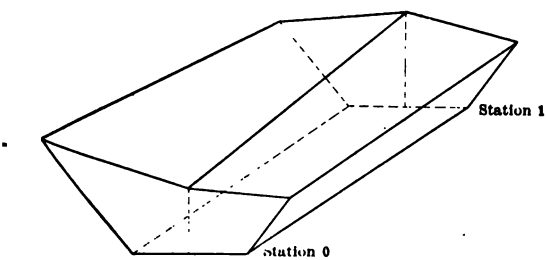
CHAPTER XII.

METHODS OF COMPUTING EARTHWORK.

222. In calculating the volumes or "quantities" of Earthwork, the principal methods used are as follows: —

I. Averaging End Areas. II. Prismoidal Formula.

223. I. Averaging End Areas.



Let A_0 = area of cross-section at Station 0

A_1 = " " " " " " " 1

l = length of section, Sta. 0 to Sta. 1

V = volume of section of earthwork (Sta. 0 to 1)

Then $V = \frac{A_0 + A_1}{2} l$ (in cubic feet) (158)

$= \frac{A_0 + A_1}{2} \cdot \frac{l}{27}$ (in cubic yards) (159)

As (158) is capable of expression $V = A_0 \frac{l}{2} + A_1 \frac{l}{2}$

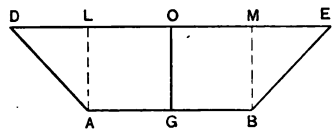
it is practically based on the assumption that the volume consists of two prisms, one of base A_0 and one of base A_1, and each of a length, or altitude of $\frac{l}{2}$.

224. To use this method, we must find the area A of each cross-section; the cross-section may be: —

(*a*) *Level.* (*b*) *Three-Level.* (*c*) *Five-Level.* (*d*) *Irregular.*

225. (*a*) **Level Cross-Section.**

Let b = base = AB s = side slope = $\frac{DL}{AL} = \frac{EM}{BM}$



c = center ht. = OG

A = area of cross-section

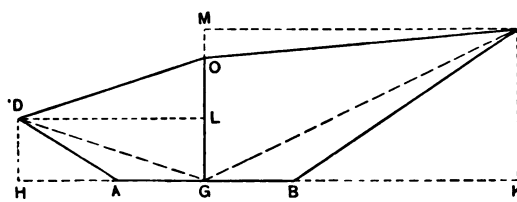
Then DL = EM = sc

A = AB × OG + DL × AL

$= bc + sc^2$

$= c(b + sc)$ (160)

226. (*b*) **Three-Level Section.** First Method.



Let b = base = AB s = side slope

c = center height

h_r = side height EK h_l = side height DH

d_r = distance out ME d_l = distance out DL

A = area of cross-section

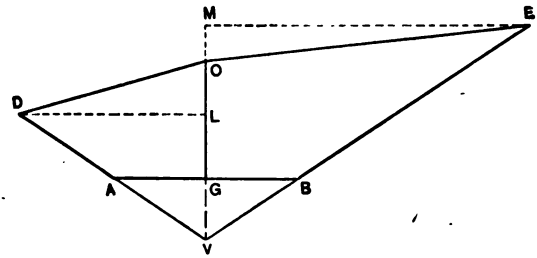
Then A = OGD + OGE + GBE + AGD

$= \frac{1}{2}$ OG × DL + $\frac{1}{2}$ OG × ME + $\frac{1}{2}$ GB × EK + $\frac{1}{2}$ AG × DH

$= \frac{1}{2}c(d_l + d_r) + \frac{1}{2}\frac{b}{2}(h_r + h_l)$

$= \frac{c(d_l + d_r) + \frac{b}{2}(h_l + h_r)}{2}$ (161)

227. (*b*) **Three-Level Section.** Second Method.



Using the same notation.

$$\frac{GB}{GV} = s$$

$$GV = \frac{GB}{s} = \frac{b}{2s}$$

$$OV = c + GV = c + \frac{b}{2s}$$

The triangle ABV is often called the "Grade Triangle."

$$\text{Area } ABV = GV \times GB$$

$$= \frac{b^2}{4s}$$

$$\text{Area } EODV = OV \times \frac{DL}{2} + OV \times \frac{ME}{2}$$

$$= \left(c + \frac{b}{2s}\right)\frac{d_l + d_r}{2}$$

$$A = EODV - ABV$$

$$= \left(c + \frac{b}{2s}\right)\frac{d_l + d_r}{2} - \frac{b^2}{4s}$$

Let $D = d_l + d_r$

$$A = \left(c + \frac{b}{2s}\right)\frac{D}{2} - \frac{b^2}{4s} \qquad (162)$$

In using this formula for a *series* of cross-sections of the same base and slope, $\frac{b}{2s}$ **and** $\frac{b^2}{4s}$ **are constants, and the computation of** A **becomes simple and more rapid than the first method.**

230. Another method which has been used for calculati irregular cross-sections is to plat them on cross-section pap and get the area by "*Planimeter.*" In very irregular cro sections this method would prove economical as compared wi direct computation by ordinary methods, but it is probable th in almost every case equal speed and equal precision can obtained by the use of suitable tables or diagrams (to be e plained later); for this reason the use of the planimeter is n recommended, certainly where diagrams are available.

231. Whatever may be the form of section, or whatever t method of computation, having found the values of A for e cross-section, the volume V is found for the End Area Meth by the formula above given.

$$V = \frac{A_0 + A_1}{2} \cdot \frac{l}{27} \text{ (in cu. yds.)} \qquad (1$$

It is found that this formula is only approximately corre Its simplicity and *substantial accuracy* in the majority of ca render it so valuable that it has become the formula in m common use. It gives results, in general, larger than the t solidity.

232. II. Prismoidal Formula.

"A prismoid is a solid having for its two ends any dissimi parallel plane figures of the same number of sides, and all t sides of the solid plane figures also."

Any prismoid may be resolved into prisms, pyramids, a wedges, having as a common altitude the perpendicular distan between the two parallel end planes.

Let A_0 and A_1 = areas of end planes.

M = area of middle section parallel to the e planes.

l = length of prismoid, or perpendicular d tance between end planes.

V = volume of the prismoid.

Then it may be shown that

$$V = (A_0 + 4\,M + A_1)\frac{l}{6}$$

233. Let B = area of lower face, or base of a prism, wedge, or pyramid.

b = area of upper face.

m = middle area parallel to upper and lower faces.

a = altitude of prism, wedge, or pyramid.

s = solidity " " " " "

Then the area of the *upper face* b in terms of *lower base* B will be for

Prism	Wedge	Pyramid
$b = B$	$b = 0$	$b = 0$

and the *middle area* m will be for

Prism	Wedge	Pyramid
$m = B$	$m = \frac{B}{2}$	$m = \frac{B}{4}$

The solidity s will be for

Prism

$$s = aB = \frac{a}{6} \cdot 6B = \frac{a}{6}(B + 4B + B) = \frac{a}{6}(B + 4m + b)$$

Wedge

$$s = \frac{aB}{2} = \frac{a}{6} \cdot 3B = \frac{a}{6}\left(B + \frac{4B}{2} + 0\right) = \frac{a}{6}(B + 4m + b)$$

Pyramid

$$s = \frac{aB}{3} = \frac{a}{6} \cdot 2B = \frac{a}{6}\left(B + \frac{4B}{4} + 0\right) = \frac{a}{6}(B + 4m + b)$$

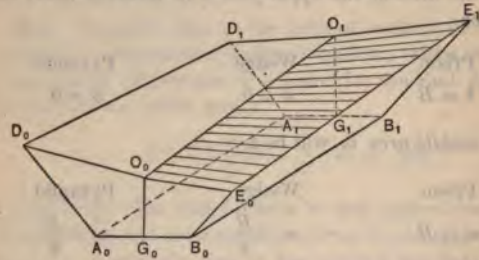
Since a prismoid is composed of prisms, wedges, and pyramids, the same expression may apply to the prismoid, and this may be put in the general form

$$V = (A_0 + 4M + A_1)\frac{l}{6} \qquad (163\text{ A})$$

using the notation of the preceding page.

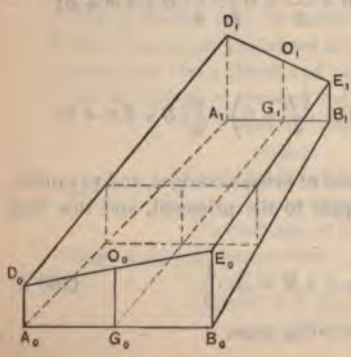
234. A regular section of earthwork having for its surface a plane face is a prismoid. Most sections of earthwork have not their surface plane, and are not strictly prismoids, although they are so regarded by some writers.

In this figure the lines E_0O_0 and E_1O_1 are not parallel, and therefore the surface $O_0O_1E_1E_0$ is not a plane. The most common assumption as to this surface is that the lines O_0O_1 and E_0E_1 are right lines, and that the surface $O_0O_1E_1E_0$ is a warped surface, generated by a right line moving as a generatrix always



parallel to the plane $O_0G_0B_0E_0$ and upon the lines O_0O_1 and E_0E_1 as directrices, as indicated in the figure. The surface thus generated is a warped surface called a "hyperbolic paraboloid." It will be shown that the "prismoidal formula" applies also to this solid, which is not, however, properly a prismoid.

235. In the following figure, which has perpendicular sides $D_0A_0A_1D_1$, $E_0B_0B_1E_1$ and the lines D_0E_0 and D_1E_1 right lines,



let $b_0 =$ base $= A_0B_0$

$b_1 =$ " $= A_1B_1$

$c_0 =$ center ht. $= O_0G_0$

$= \dfrac{D_0A_0 + E_0B_0}{2}$

$c_1 =$ center ht. $= O_1G_1$

$= \dfrac{D_1A_1 + E_1B_1}{2}$

$l =$ length (altitude) of section $= G_0G_1$

$A_0 =$ area of $D_0A_0B_0E_0$

$A_1 =$ area of $D_1A_1B_1E_1$

$V =$ volume

Also use notation b_x, c_x, A_x for a section distant x from G_1.

Then

$$A_0 = b_0 c_0 \qquad A_1 = b_1 c_1$$

$$b_x = b_1 + (b_0 - b_1)\frac{x}{l}$$

$$c_x = c_1 - (c_1 - c_0)\frac{x}{l} = c_1 + (c_0 - c_1)\frac{x}{l}$$

$$A_x = b_x c_x = \left[b_1 + (b_0 - b_1)\frac{x}{l}\right]\left[c_1 + (c_0 - c_1)\frac{x}{l}\right]$$

$$V = \int_0^l \left[b_1 + (b_0 - b_1)\frac{x}{l}\right]\left[c_1 + (c_0 - c_1)\frac{x}{l}\right] dx$$

$$= b_1 c_1 l + [b_1(c_0 - c_1) + c_1(b_0 - b_1)]\frac{l^2}{2l} + \frac{(b_0 - b_1)(c_0 - c_1)l^3}{3l^2}$$

$$= \frac{l}{6}\left\{\begin{array}{l} 6\,b_1c_1 + 3\,b_1c_0 + 3\,b_0c_1 + 2\,b_0c_0 \\ -3\,b_1c_1 - 2\,b_1c_0 - 2\,b_0c_1 \\ -3\,b_1c_1 \\ +2\,b_1c_1 \end{array}\right\}$$

$$V = \frac{l}{6}(2\,b_1c_1 + 2\,b_0c_0 + b_1c_0 + b_0c_1) \qquad (164)$$

236. Apply the "Prismoidal Formula" to the same section. The base and center height of the middle section are :—

$$b_m = \frac{b_0 + b_1}{2} \qquad c_m = \frac{c_0 + c_1}{2}$$

$$A_0 = b_0 c_0 \qquad A_1 = b_1 c_1$$

$$M = \frac{b_0 + b_1}{2} \times \frac{c_0 + c_1}{2} = \text{area of middle section}$$

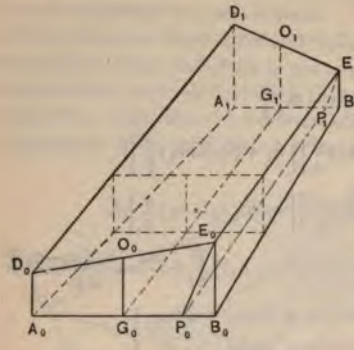
$$V = \frac{l}{6}(A_0 + 4M + A_1)$$

$$= \frac{l}{6}(b_0c_0 + b_0c_0 + b_0c_1 + b_1c_0 + b_1c_1 + b_1c_1)$$

$$= \frac{l}{6}(2\,b_1c_1 + 2\,b_0c_0 + b_1c_0 + b_0c_1) \qquad (165)$$

This is the same as formula (164) found above to be correct for the warped surface. Therefore the "Prismoidal Formula" (163 *A*) applies to the section shown in § 235.

237. The sections of earthwork commonly used in railr work are bounded not by perpendicular sides, but by incli planes.



In the figure, supp a plane to be pas through the line E_0 cutting A_0B_0 at P_0 a A_1B_1 at P_1. The p moidal formula appl to the solid $E_0P_0B_0B_1E$ cut out by this pla since this solid is a t prismoid. If the p moidal formula appl to the entire solid, a also to the part cut o it must apply to the maining solid $D_0A_0P_0E_0E_1P_1A_1D_1$, and this represents in fo one side of a regular three-level section of earthwork in wh D_0A_0 represents the center height and E_0P_0 the slope.

If the prismoidal formula applies to the section upon one s of the center, it applies also to the other side, and so to t entire section.

238. The "*Prismoidal Formula*" is of wide applicati Since it applies to prisms, wedges, pyramids, and to sol bounded by warped surfaces generated as described, it follo that it applies to any solid bounded by two parallel plane fa and defined by the surfaces generated by a right line movi upon the perimeters of these faces as directrices. It may a be stated here without demonstration that it also applies to t *frusta* of all solids generated by the revolution of a conic s tion as well as to the complete solids, for instance, the spher

The prismoidal formula is generally accepted as correct the computation of earthwork and similar solids, and the me urements of a section of earthwork are taken so as to rep sent properly the surface of the ground if this be a warp surface of the sort described. The failure to use the prismoi formula is explained often by the additional labor necessa for its use.

239. For "three-level" sections of earthwork, a result correct by the prismoidal formula may be secured, and the work simplified, by calculating the quantities first by the inexact method of "end areas," and then applying a *correction* which we may call "**The Prismoidal Correction.**"

Let V_e = solidity by end areas

V_p = " " prismoidal formula

Then $C = V_e - V_p$ = prismoidal correction

In the figure, § 235,

$$V_p = \text{by formula (164)} = \frac{l}{6}(2\,b_1c_1 + 2\,b_0c_0 + b_1c_0 + b_0c_1)$$

$$V_e = \frac{l}{2}\,(b_1c_1 + b_0c_0) \quad = \frac{l}{6}(3\,b_1c_1 + 3\,b_0c_0)$$

$$C = V_e - V_p = \frac{l}{6}\,(b_1c_1 + \quad b_0c_0 - b_1c_0 - b_0c_1)$$

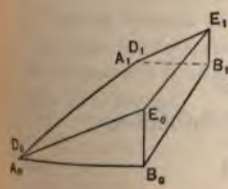
$$= \frac{l}{6}\,(b_1 - b_0)(c_1 - c_0)$$

Let $D_0A_0 = h_0'$ $\qquad$ $D_1A_1 = h_1'$

$E_0B_0 = h_0$ $\qquad$ $E_1B_1 = h_1$

Then $$C = \frac{l}{6}\,(b_1 - b_0)\left(\frac{h_1 + h_1'}{2} - \frac{h_0 + h_0'}{2}\right)$$

$$= \frac{l}{12}(b_1 - b_0)\,(h_1 + h_1' - h_0 - h_0')$$

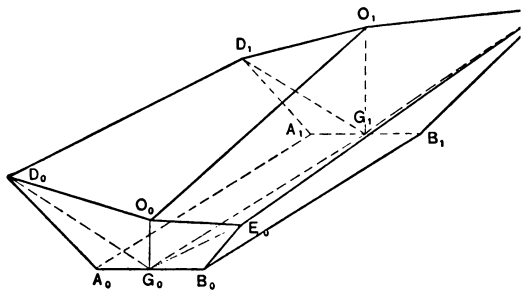


When the solid assumes a triangular cross-section, as in the figure,

$h_0' = 0$ $\qquad$ $h_1' = 0$

$$C = \frac{l}{12}\,(b_1 - b_0)(h_1 - h_0) \quad (166)$$

240. If any solid be divided into a number of solids triangular cross-section, the above correction may be ap each such triangular solid, and the sum of the correcti be the correction for the entire solid.



Let this figure represent a section of earthwork divic three parts, as indicated by the lines D_0G_0, E_0G_0, D_1G_1, I

Then, for the solid $O_0D_0G_0E_0E_1G_1D_1O_1$,

$$C = \frac{l}{12}[(c_1 - c_0)(d_{l_1} - d_{l_0}) + (c_1 - c_0)(d_{r_1} -$$

$$= \frac{l}{12}(c_1 - c_0)(d_{l_1} + d_{r_1} - d_{l_0} - d_{r_0})$$

Let $D_1 = d_{l_1} + d_{r_1}$ and $D_0 = d_{l_0} + d_{r_0}$

$$C = \frac{l}{12}(c_1 - c_0)(D_1 - D_0)$$

For the solid $G_0B_0E_0E_1B_1G_1$,

(166) $$C = \frac{l}{12}\left(\frac{b_1}{2} - \frac{b_0}{2}\right)(h_{r_1} - h_{r_0})$$

$$= \frac{l}{12}(0)(h_{r_1} - h_{r_0})$$

$$= 0$$

Similarly for the solid $A_0G_0D_0D_1G_1A_1$.

Hence for the entire solid $A_0B_0E_0O_0D_0D_1O_1E_1B_1A_1$.

$$C = \frac{l}{12}(c_1 - c_0)(D_1 - D_0)$$

When $l = 100$

$$C_{100} = \frac{100}{12 \times 27}(c_1 - c_0)(D_1 - D_0)$$

$$= \frac{1}{3.24}(c_1 - c_0)(D_1 - D_0) \text{ in cu. yds.} \quad (168)$$

Since $C = V_e - V_p$, $V_p = V_e - C$ (169)

When $(c_1 - c_0)(D_1 - D_0)$ is *positive*, the correction C is to be *subtracted* from V_e.

When $(c_1 - c_0)(D_1 - D_0)$ is *negative*, the arithmetical value of C is to be *added* to V_e. The latter case seldom occurs in practice, except where C is very small, perhaps small enough to be neglected.

For the purposes of the prismoidal correction it should be borne in mind that the signs + or − mean simply *cut* or *fill*, and *should not be considered* in determining whether to add or subtract the correction.

For a section of length l, $C_l = \frac{l}{100} C_{100}$

$$V_{pl} = \frac{l}{100}(V_{e100} - C_{100}) \quad (169\,A)$$

The prismoidal correction has two principal forms. For a solid bounded by ends of triangular section the form is

$$C = \frac{l}{12}(b_1 - b_0)(h_1 - h_0) \quad (166)$$

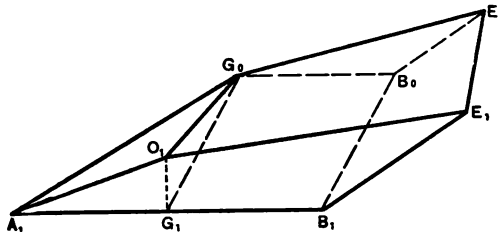
This should be considered the fundamental form. In the case of regular "Three Level Sections" it takes a secondary or special form

$$C = \frac{l}{12}(c_1 - c_0)(D_1 - D_0) \quad (167)$$

This last formula can be used only when the width of base is the same at both ends of the section. From the method of its derivation it is evident that for the right half of a regular three level section

$$C_r = \frac{l}{12}(c_1 - c_0)(d_{r_1} - d_{r_0}) \quad (167\,A)$$

241. In passing from cut to fill as in the figure

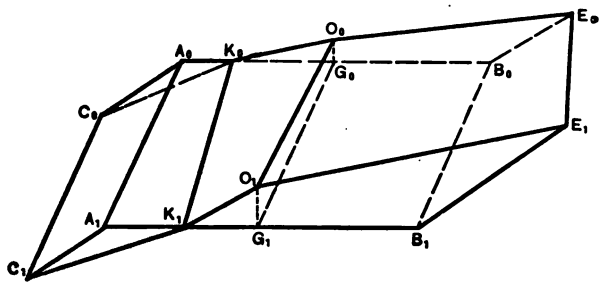


for the right half $C_r = \frac{l}{12}(c_1 - c_0)(d_{r_1} - d_{r_0})$ from (167 *A*)

for the left side $C_l = \frac{l}{12}(c_1 - c_0)\left(\frac{b}{2} - 0\right)$ from (166)

$$C = \frac{l}{12}(c_1 - c_0)(D_1 - d_{r_0})$$

For the special case of a side hill section



the prismoidal correction for cut will be

$$C_c = \frac{l}{12}(c_1 - c_0)(d_{r1} + d_{k_1} - \overline{d_{r_0} + d_{k_0}})$$

the prismoidal correction for fill will be

$$C_f = \frac{l}{12}\left(c_1 - c_0\right)\left(\frac{b}{2} - d_{k_1} - \overline{\frac{b}{2} - d_{k_0}}\right)$$

$$= \frac{l}{12}(c_1 - c_0)(d_{k_0} - d_{k_1})$$

242. Formula (166) can also be used to find the correction for the triangular pyramids (for excavation Sta. 2+76 to 2+87, and embankment 2 + 64 to 2 + 76), *each end of the pyramid* being considered to have a triangular section. A much simpler way to find the correction for a pyramid is this,

$$C = V_e - V_p = \frac{1}{3} V_e$$

as may readily be shown to be true for any pyramid, since

$$V_e = A\frac{l}{2}$$

$$V_p = A\frac{l}{3}$$

$$C = V_e - V_p = A\frac{l}{6} \qquad (170)$$

since by the End Area method $V_e = A\frac{l}{2} + 0$

$$C = \frac{V_e}{3} \qquad (171)$$

243. In the case of regular "**Five-Level Sections,**" as shown in the figure, p. 152, the prismoidal correction may be computed for each of the triangular masses bounded by

1. LGM 2. MEBG 3. LDAG

In the case of LGM, the prismoidal correction will evidently be = 0, since $D_0 = \mathrm{AB} = D_1$, and therefore $D_0 - D_1 = 0$.

The correction for the mass bounded on one end by

$$\mathrm{MEBG} = C = \frac{l}{12}(f_{r_0} - f_{r_1})(d_{r_0} - d_{r_1}) \quad \text{from (166)}$$

and by $$\mathrm{LDAG} = C = \frac{l}{12}(f_{l_0} - f_{l_1})(d_{l_0} - d_{l_1}) \quad \text{from (166)}$$

244. In the case of "**Irregular Sections,**" the prismoidal correction cannot with convenience be accurately employed. There are, however, several methods by which we may calculate a "prismoidal correction" which will be approximately correct, and good enough for practical purposes.

Inspection of the formula $C = \frac{l}{12}(c_1 - c_0)(D_1 - D_0)$ (167) makes it clear that the correction will be large when the two end sections differ much in size, and small when the end sections are nearly equal. Ordinarily in a large section both c and D are large. For any *given area of section* in a regular three-level section, if c is made smaller, D must be increased in nearly like measure, and formula (167) will show little change in the value of C even if c be changed, if the area remains the same.

For the purpose *only* of finding the prismoidal correction there are several approximate methods based on the principle above stated.

1. Where the section is only slightly irregular. Neglect all intermediate heights and figure correction from c and D. This is a very simple method.

Where more careful results seem desirable,

2. Find c and D for an "equivalent level section"; that is, a level section of equal area to the irregular section. Use the c and D thus determined in computing the prismoidal correction. These can be used with the c and D of a regular three-level section, or with the c and D of another equivalent level section.

The c and D of the equivalent level section may be found from Tables or from Diagrams, whose use will be shown in later chapters.

3. Find an equivalent regular three-level section (not level) either by

(a) retaining c and computing D, or

(b) retaining D and computing c.

The method of doing this will be made simple by Diagrams described in a later chapter.

4. Plot the irregular section on cross-section paper, and draw lines to form a regular three-level section which will closely approximate, in form, to the irregular section, and find c and D.

While the results obtained by any of the above methods are approximate, the resulting error can be only a small fraction of the entire correction, which is itself small.

The method of averaging end areas and applying the prismoidal correction allows of great rapidity, and secures great precision, and well meets the requirements of modern railroad practice.

CHAPTER XIII.

SPECIAL PROBLEMS.

245. Correction for Curvature.

In the case of a curve, the ends of a section of earthwork are not parallel, but are in each case normal to the curve. In calculating the solidity of a section of earthwork, we have heretofore assumed the ends parallel, and for curves this is equivalent to taking them perpendicular to the chord of the curve between the two stations.

Then, as shown in Fig. 1 (where IG and GT are center-line chords), the solidity (as above) of the sections IG and GT will be too great by the wedge-shaped mass RGP, and too small by

FIG. 1.

QGS. When the cross-sections on each side of the center are equal, these masses balance each other. When the cross-section on one side differs much in area from that on the other, the correction necessary may be considerable.

In Fig. 2, use c, h_l, h_r, d_l, d_r, b, s, as before.
Let D = degree of curve. Make BL = AD, and join OL.

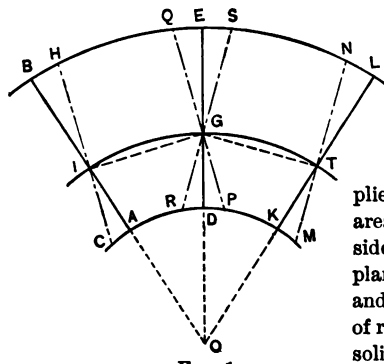


FIG. 1.

Then ODAG balances OLBG, and there remains an unbalanced area OLE.

Draw OKP parallel to AB.

By the "Theorem of Pappus" (see Lanza, Applied Mechanics), "If a plane area lying wholly on the same side of a straight line in its own plane revolves about that line, and thereby generates a solid of revolution, the volume of the solid thus generated is equal to the product of the revolving area and of the path described by the center of gravity of the plane area during the revolution."

The correction for curvature, or the solidity, developed by this triangle OLE (Fig. 2) revolving about OG as an axis will be its area × the distance described by its center of gravity. The distance out (horizontal) to the center of gravity from the axis (center line) will be two thirds of the mean of the distances out to E and to L, or

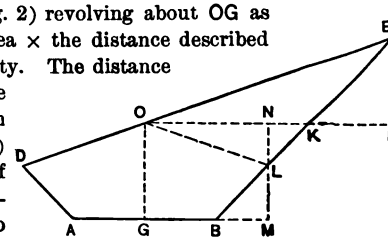


FIG. 2.

$$= \frac{2}{3} \cdot \frac{d_l + d_r}{2}$$

and the distance described will be

$$\frac{2}{3} \cdot \frac{d_l + d_r}{2} \times \text{angle QGS}$$

The area $$\text{OLE} = \text{OK} \times \frac{\text{NL} + \text{PE}}{2}$$

$$= \left(\frac{b}{2} + sc\right) \frac{h_r - h_l}{2}$$

Therefore the correction for curvature,

$$C = \left(\frac{b}{2} + sc\right) \cdot \frac{h_r - h_l}{2} \cdot \frac{d_r + d_l}{3} \times \text{angle QGS}$$

When IG, GT are each a full station, or 100 ft. in length,

$$\text{QGS} = D$$

$$C = \left(\frac{b}{2} + sc\right) \cdot \frac{h_r - h_l}{2} \cdot \frac{d_r + d_l}{3} \times \text{angle } D$$

arc $1° = .01745$

$$C = \left(\frac{b}{2} + sc\right) \frac{h_r - h_l}{2} \times \frac{d_r + d_l}{3} \times 0.01745\, D$$

$$= \left(\frac{b}{2} + sc\right)(h_r - h_l)(d_r + d_l) \times 0.00291\, D \text{ (cu. ft.)} \qquad (172)$$

$$= \left(\frac{b}{2} + sc\right)(h_r - h_l)(d_r + d_l) \times 0.00011\, D \text{ (cu. yds.)} \qquad (173)$$

246. When IG or GT, or both, are less than 100 ft., let

$$\text{IG} = l_0 \qquad \text{and} \qquad \text{GT} = l_1$$

Then $$\text{QGE} = \frac{l_0}{100} \times \frac{D}{2} \text{ and } \text{SGE} = \frac{l_1}{100} \times \frac{D}{2}$$

$$\text{QGS} = \frac{l_0 + l_1}{200} D$$

$$C = \left(\frac{b}{2} + sc\right)(h_r - h_l)(d_r + d_l)\frac{l_0 + l_1}{200} \times 0.00011\, D \text{ (cu. yds.)} \qquad (174)$$

247. The correction C is to be added when the greater area is on the outside of the curve, and subtracted when the greater area is on the inside of the curve. When the center height is 0, as in Fig. 3, we may consider this a regular section in which $c = 0$, $h_l = 0$, and $d_l = \frac{b}{2}$; then

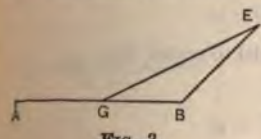


FIG. 3.

$$C = \frac{b}{2} \times h_r \times \left(d_r + \frac{b}{2}\right)\frac{l_0 + l_1}{200} \times 0.00011\, D \text{ (cu. yds.)} \qquad (175)$$

In the case of an irregular section, as shown in Fig. 4, the area and distance to center of gravity (for example, of OHEML) may be found by any method available, and the correction

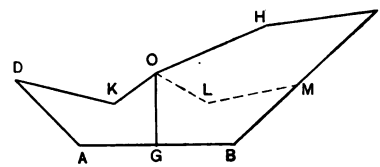
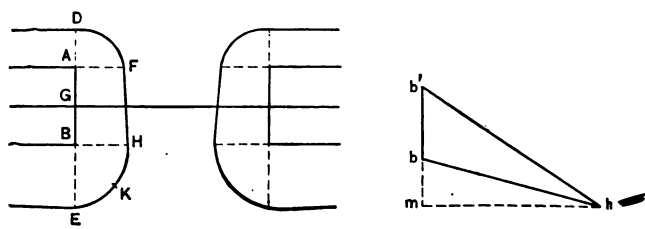


FIG. 4.

figured accordingly. The correction for curvature is, in present railroad practice, more frequently neglected than used. Nevertheless, its amount is sufficient in many cases to fully warrant its use.

248. Opening in Embankment.

Where an opening is left in an embankment, there remains outside the regular sections the mass DEKHF.



This must be calculated in 3 pieces, ADF, BEKH, ABHF.

Let b = base = AB

d_r = distance out right

d_l = distance out left

p_r = BH, p_l = AF } taken parallel to center line

f_r = , f_l = } heights at { B, A

s_1 = solidity ADF

s_2 = BEKH

s_3 = ABHF

Then (approximately) following the "Theorem of Pappus," s_1 = mean of triangular sections AD and AF × distance described by center of gravity.

In the quarter cone AFD, AF = p_l

$$AD = d_l - \frac{b}{2}$$

Then average radius $R_l = mh = \frac{AF + AD}{2}$

Area of vertical triangular section $A_l = \frac{f_l R_l}{2}$

Distance from A to center of gravity of vertical section $= \frac{R_l}{3}$

Arc described by center of gravity $= \frac{R_l}{3} \times \frac{\pi}{2} = \frac{\pi R_l}{6}$

$$s_1 = \frac{f_l R_l}{2} \times \frac{\pi R_l}{6} \text{ (cu. ft.)}$$

$$= \frac{f_l R_l^2 \times 3.1416}{2 \times 6 \times 27} \text{ (cu. yds.)}$$

$$s_1 = 0.0097 f_l R_l^2 \text{ (cu. yds.)} \quad (176)$$

Similarly, in the quarter cone BEKH

The average radius $R_r = \frac{BH + 2BK + BE}{4}$

$$s_2 = \frac{f_r R_r}{2} \times \frac{\pi R_r}{6} \text{ (cu. ft.)}$$

$$s_2 = 0.0097 f_r R_r^2 \text{ (cu. yds.)} \quad (177)$$

For the solid AGBHF

$$s_3 = \frac{\text{area AF} + \text{area BH}}{2} \times AB$$

$$= \frac{(f_l p_l + f_r p_r) b}{4} \quad (178)$$

The work of deriving formulas (176) and (177) is approximate throughout, but the total quantities involved are in general not large, and the error resulting would be unimportant.

There seems to be no method of accurately computing this solidity which is adapted to general railroad practice.

249. Borrow-Pits.

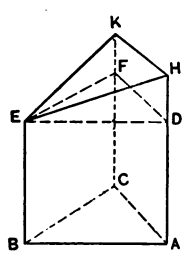
In addition to the ordinary work of excavation and embankment for railroads, earth is often "borrowed" from outside the limits of the work proper; and in such excavations called "borrow-pits," it is common to prepare the work by dividing the surface into squares, rectangles, or triangles, taking levels at every corner upon the original surface; again, after the excavation of the borrow-pit is completed, the points are reproduced and levels taken a second time. The excavation is thus divided into a series of vertical prisms having square, rectangular, or triangular cross-sections. These prisms are commonly truncated top and bottom. The lengths or altitudes of the vertical edges of these prisms are given by the difference in levels taken,

1st, on the original surface, and

2d, after the excavation is completed.

This method of measurement is very generally used, and for many purposes.

250. Truncated Triangular Prisms.



Let A = area of right section EFD of a truncated prism, the base ABC being a right section

h_1 = height AH

h_2 = " BE

h_3 = " CK

a = altitude of triangle EFD dropped from E to FD

Let V = volume of prism ABCKHE

s_l = solidity " " ABCFDE

s_u = " " pyramid FDEHK

Then $s_t = A \times AD = A \times \frac{3\,AD}{3} = A \times \frac{AD + BE + CF}{3}$

$s_u = \text{area DFKH} \times \frac{a}{3}$

$= \frac{KF + HD}{2} \times FD \times \frac{a}{3}$

$= \frac{KF + HD}{3} \times FD \times \frac{a}{2}$

$= \frac{KF + HD}{3} \times A$

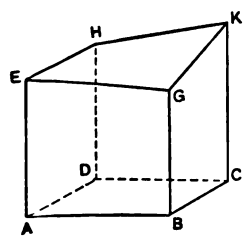
$V = s_t + s_u = A\left(\frac{AD + BE + CF}{3} + \frac{KF + HD}{3}\right)$

$= A\frac{(AD + HD) + BE + (CF + KF)}{3}$

$= A\frac{h_1 + h_2 + h_3}{3}$ (179)

If the prism be truncated top and bottom, the same reasoning holds and the same formula applies.

251. Truncated Rectangular Prism.



Let A = area of right section ABCD of a rectangular prism truncated on top (base is ABCD)

h_1 = height AE

h_2 = " BG

h_3 = " KC

h_4 = " HD

V = volume of prism

b = AD = BC

a = AB = DC

Then using method of end areas,

$$V = \frac{\text{AEHD} + \text{BGKC}}{2} \times a$$

$$= \frac{b\frac{h_1 + h_4}{2} + b\frac{h_2 + h_3}{2}}{2} \times a$$

$$= ab\,\frac{h_1 + h_2 + h_3 + h_4}{4}$$

$$V = A\,\frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. ft.)} \qquad (180)$$

$$V = \frac{A}{27} \cdot \frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. yds.)} \qquad (181)$$

We may find V, correct by the prismoidal formula, if we apply the prismoidal correction. The prismoidal correction $C = 0$, since $D_0 - D_1 = 0$ (or in this case AD − BC = 0). The formula therefore remains unchanged. It is evident from this, then, that the solution holds good, and the formula is correct, not only when the surface EHKG is a plane, but also when it is a warped surface generated by a right line moving always parallel to the plane ADHE, and upon EG and HK as directrices.

Some engineers prefer to cross-section in rectangles of base $15' \times 18'$. In this case

$$V = \frac{15' \times 18'}{27} \cdot \frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. yds.)}$$

$$= 10\,\frac{h_1 + h_2 + h_3 + h_4}{4} \text{ (cu. yds.)} \qquad (182)$$

Other convenient dimensions will suggest themselves, as

$$10' \times 13.5' \quad \text{or} \quad 20' \times 13.5' \quad \text{or} \quad 20' \times 27'$$

By this method the computations are rendered slightly more convenient; but the size of the cross-section, and the shape, whether square or rectangular, should depend on the topography. The first essential is accuracy in results, the second is simplicity and economy in field-work, and ease of computation should be subordinate to both of these considerations.

252. Assembled Prisms.

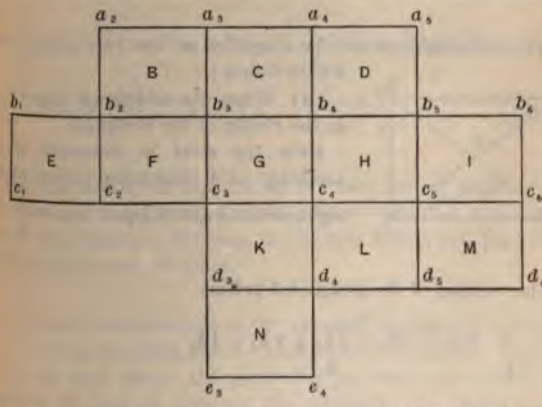
In the case of an assembly of prisms of equal base, it is not necessary to separately calculate each prism, but the solidity of a number of prisms may be calculated in one operation.

In the prism B,

$$V_B = A\frac{a_2 + a_3 + b_3 + b_2}{4}$$

$$V_C = A\frac{a_3 + a_4 + b_4 + b_3}{4}, \text{ etc.}$$

From inspection it will be seen, taking A as the common area of base of a single prism, and taking the sum of the solidities, that the heights a_2, a_5 enter into the calculation of



one prism only; a_3, a_4 into two prisms each; b_1, b_6 one only; b_2, b_5 into three prisms; b_3, b_4 into four prisms; and similarly throughout.

Let t_1 = sum of heights common to one prism
t_2 = " " " " " two prisms
t_3 = " " " " " three "
t_4 = " " " " " four "

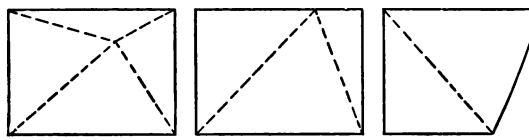
Then the total volume,

$$V_t = A\frac{t_1 + 2t_2 + 3t_3 + 4t_4}{4} \text{ (cu. ft.)} \qquad (183)$$

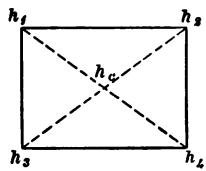
$$V_t = \frac{A}{27} \cdot \frac{t_1 + 2t_2 + 3t_3 + 4t_4}{4} \text{ (cu. yds.)} \qquad (184)$$

253. Additional Heights.

When the surface of the ground is rough it is not unusual to take additional heights, the use of which, in general, involves appreciable labor in computation, it being necessary commonly to divide the solid into triangular prisms, as suggested by the figures just below, which include the case of a trapezoid.



The computations may be simplified in the two special cases which follow:



(*a*) When the additional height h_c is in the center of the rectangle.

Here the solid is composed of an assembly of 4 triangular prisms whose right sections are of equal area $= \frac{A}{4}$.

The volume of the assembled prisms

$$V = \frac{A}{4} \cdot \frac{2h_1 + 2h_2 + 2h_3 + 2h_4 + 4h_c}{3}$$

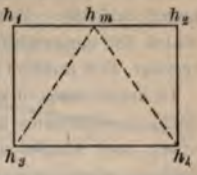
$$= \frac{A}{12}(2h_1 + 2h_2 + 2h_3 + 2h_4 + 4h_c)$$

$$= \frac{A}{12}(3h_1 + 3h_2 + 3h_3 + 3h_4) + \frac{A}{12}(4h_c - h_1 - h_2 - h_3 - h$$

$$V = A\frac{h_1 + h_2 + h_3 + h_4}{4} + \frac{A}{3}\left(h_c - \frac{h_1 + h_2 + h_3 + h_4}{4}\right) \quad (18$$

or the total volume is that due to the four corner heights p the volume of a pyramid of equal area of base and whose al *tude is the* difference between the center height and the me *of the four* corner heights.

(*b*) When the additional height is at the middle of one side of the rectangle.



$$V=\frac{1}{3}\cdot\frac{A}{4}(h_1+h_m+h_3+h_2+h_4+h_m)+$$

$$\frac{1}{3}\cdot\frac{A}{2}(h_m+h_4+h_3)$$

$$V=\frac{A}{12}(h_1+h_m+h_3+h_2+h_4+h_m+2h_m+2h_4+2h_3)$$

$$=\frac{A}{12}(h_1+h_2+3h_3+3h_4+4h_m)$$

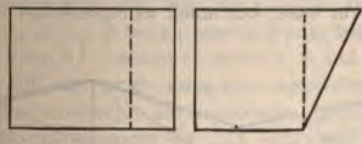
$$=\frac{A}{12}(3h_1+3h_2+3h_3+3h_4)+\frac{A}{12}(4h_m-2h_1-2h_2)$$

$$=A\frac{h_1+h_2+h_3+h_4}{4}+\frac{A}{3}\left(h_m-\frac{h_1+h_2}{2}\right) \qquad (185\,A)$$

or the total solidity is that due to the four corner heights plus the solidity of a pyramid of equal area of base and whose altitude is the difference between the middle height and the mean of the adjacent side heights.

Apparently the principle of the pyramid applies conveniently only in these two cases.

For the case where the point lies on one of the sides, an alternate method of dividing the rectangle (or trapezoid) is indicated below.



The details of the computation in this case need not be worked out here.

254. The common practice in the case of borrow-pits is stated in § 249. When the original surface and the surfa which the excavation is made are both somewhat rough an regular, this method is naturally and properly adopted.

In many cases of excavation, the work is carried to a fini surface, sometimes a plane surface, or several planes, or s other very simple surface, sometimes to a more complic surface where cross-sectioning the finished surface would readily allow the facts to be shown on the plan.

In either of these cases the following method seems prefer

(*a*) Cross-section the original surface as before.

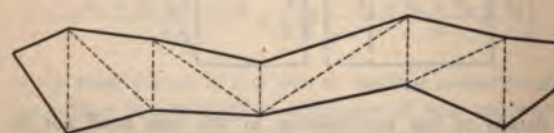
(*b*) Assume a convenient horizontal plane, slightly l than the surface to which the excavation has been carried.

(*c*) Find the total earthwork to the original cross-secti surface, above this assumed plane as a base.

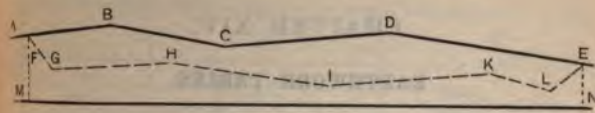
(*d*) Find the total earthwork to the finished surface, a the assumed plane as a base. In many cases this surface w bounded by only a few planes and thus will allow very si computations.

(*e*) Find the difference between (*c*) and (*d*); this will the amount of earthwork excavated.

255. It often happens that an excavation is made of siderable length and not great breadth, and often of great depth. In stripping soil under a proposed embank these conditions prevail. The excavation can then be handled very much as excavation is handled on railroads *line* will be run, and a series of cross-sections taken, the serving as a center line, and cross-sections being taken stations along the line as often as required by the surface ditions. The cross-sections will be very irregular, not ing any uniform base, but much as represented in the f below.



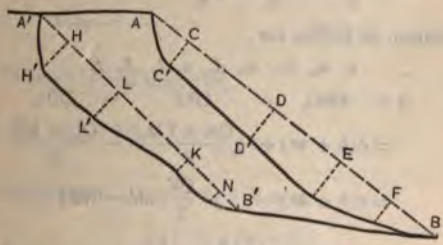
256. To find the area of these irregular sections, it may frequently happen that the best method may be one similar to that described for cross-sectioning on the preceding page.



(*a*) Find elevations on original surface ABCDE.
(*b*) Find elevations on excavated surface FGHIKLE.
(*c*) Assume a horizontal line at a convenient elevation MN.
(*d*) Calculate area MFBCDEN.
(*e*) Calculate area MFGHIKLEN.
(*f*) Area required is the difference between (*d*) and (*e*).

257. It is frequently necessary to find the excavation made by digging into the side of a high bank. Cross-section points on a steep slope, often in loose sand, cannot be expected to yield good results for computing excavation.

In such cases the following method may prove valuable.



(*a*) Determine with care both the position and elevation of point A at edge of top of bank; also of B near bottom of slope.

(*b*) Sight from A to bottom of stake at B and read on leveling rod CC′, DD′, etc., at the same time measuring AC, AD, etc.

(*c*) After the excavation has been made, find the positions of A′ and B′; also the distances HH′, LL′, etc.; also A′H, A′L, etc.

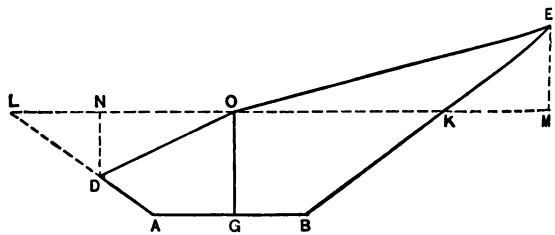
(*d*) Plot on cross-section paper and measure area between original surface and excavated surface. This can probably be done to best advantage by planimeter.

CHAPTER XIV.

EARTHWORK TABLES.

258. The calculation of quantities can be much facilitated by the use of suitably arranged "Earthwork Tables."

For regular "Three-Level Sections" very convenient tables can be calculated upon the following principles or formulas:—



Use notation as before for

$$c,\ h_l,\ h_r,\ d_l,\ d_r,\ s,\ l,\ A,\ S$$

Then $A =$ ABKL $+$ OKE $-$ ODL

$$= c(b + sc) + \frac{\text{OK} \times \text{EM}}{2} - \frac{\text{OL} \times \text{ND}}{2}$$

$$= c(b + sc) + \frac{\text{OK}}{2}(\text{EM} - \text{ND})$$

$$= c(b + sc) + \frac{1}{2}\left(\frac{b}{2} + sc\right)(h_r - c - c + h_l)$$

$$A = c(b + sc) + \frac{1}{2}\left(\frac{b}{2} + sc\right)(h_l + h_r - 2c)$$

For a prism of base A and $l = 50$, the solidity

$$S = 50\,A \text{ (cu. ft.)} = \frac{50}{27}\,A \text{ (cu. yds.)}$$

$$S = \frac{50}{27}c(b + sc) + \frac{25}{27}\left(\frac{b}{2} + sc\right)(h_l + h_r - 2c) \text{ (cu. yds.)} \quad (186$$

259. For cross-sections of a given base and slope, that is, given b and s constant, we may calculate for successive values of c, and tabulate values of L and K as follows: —

	L	K
c	$\frac{50}{27}c(b+sc)$	$\frac{25}{27}\left(\frac{b}{2}+sc\right)$

L represents the solidity for the *level section.*

K is for use as a correction. The formula then adapts itself to this table for any desired values of c, h_l, h_r.

$$S = L + K(h_l + h_r - 2c) \qquad (186\ A)$$

Having found for successive stations S_0 and S_1 (each for a prism $l = 50$), then for the *full section* by "end areas,"

$$V_{c100} = S_0 + S_1$$

for
$$V_{c100} = \frac{A_0 + A_1}{2} \cdot \frac{100}{27} = \frac{50\,A_0}{27} + \frac{50\,A_1}{27}$$

$$V_{c100} = S_0 + S_1 \qquad (187)$$

260. When l is less than 100,

$$V_{cl} = (S_0 + S_1)\frac{l}{100} \qquad (188)$$

For level sections $h_l = h_r = c$

$$h_l + h_r - 2c = 0$$

and the formula

$$S = L + K(h_l + h_r - 2c)$$

becomes $S = L$ (189)

for level sections, and the quantities for any given values of c can be directly taken from column L without any correction from column K.

In preliminary estimates, or wherever center heights only are used, such tables are rapidly used.

261. Tables may be found in Allen's Tables XXXII various bases for

$b = 20$	$s = 1\frac{1}{2}$ to 1	p.
$b = 14$	$s = 1\frac{1}{2}$ to 1	p.

An example will illustrate their use,

$b = 14$ $\quad$ $s = 1\frac{1}{2}$ to 1

Notes : —

Sta. 1	$\frac{16.0}{-6.0}$	-3.7	$\frac{12.4}{-3.6}$
0	$\frac{10.6}{-2.4}$	-2.5	$\frac{10.3}{-2.2}$

Calculations : —

3.7	$L = 134.0$	$K = 11.6$	$h_l + h_r = 9.6$
	$+ \underline{25.5}$	$\underline{2.2}$	$2c = \underline{7.4}$
	$S_1 = 159.5$	2.32	$+2.2$
		$\underline{23.2}$	
		25.52	
2.5	$L = 82.2$	$K = 10.0$	$h_l + h_r = 4.6$
	$- \underline{4.0}$	$\underline{0.4}$	$2c = \underline{5.0}$
	$S_0 = 78.2$	4.00	-0.4

$V_{100} = S_1 + S_0 = 237.7$

262. There is also in Allen's Tables XXXI a "Table Prismoidal Correction" calculated by the formula

$$C = \frac{1}{3.24}(c_0 - c_1)(D_0 - D_1)$$

In the example above

$$c_0 - c_1 = 2.5 - 3.7 = -1.2$$
$$D_0 - D_1 = 20.9 - 28.4 = -7.5$$

From Table find opp. 7.5 for 1 $\quad$ 2.31

2 $\quad$ $\frac{4.63}{0.46}$ (10

$V_{100} = V_s = 237.7$ $\quad$ 0.2 $\quad$ $\underline{0.46}$

$C = \underline{2.8}$ $\quad$ $C = 2.77$

$V_p = 234.9$

263. When the section is less than 100 ft. in length, the prismoidal correction is made before multiplying by $\frac{l}{100}$

that is, $$V_{pl} = (S_0 + S_1 - C)\frac{l}{100} \qquad (190)$$

264. Equivalent Level Sections.

The Table of p. 179 (or Table XXXII, Allen's Tables) shows in the L column the value of $S = \frac{50}{27}A$ for values of center height c. Conversely if there be given the S of any section, "irregular" or "regular three level," the value of c for a level section of the same area may be found from the L column.

Example. From p. 180, Base 14, Slope $1\frac{1}{2}$ to 1 for

$S_1 = 159.5$ $\quad c = 4.2$ $\quad$ from Table XXXII

The notes of this section will be

$$\frac{13.3}{-4.2} \qquad -4.2 \qquad \frac{13.3}{-4.2}$$

265. For general calculations adapted both to regular "Three-Level Sections" and to "Irregular Sections," tables can be calculated upon the following principles and formulas: —

These tables are, in effect, tables of "Triangular Prisms," in which, having given (in feet) the base B and altitude a of any triangle, the tables give the solidity (in cubic yards) for a prism of length $l = 50$; that is,

$$S = \frac{aB}{2} \cdot \frac{50}{27} = \frac{50}{54}aB \qquad (191)$$

Whenever the calculations can be brought into the form $S = \frac{50}{54}aB$, the result can be taken directly from the table.

266. In Allen's Field and Office Tables, "Three-Level Sections" are provided for in Table XXXII for slope of $1\frac{1}{2}$ to 1 and bases 14 to 30. "Prismoidal Corrections" are found in Table XXXI; and "Triangular Prisms" in Table XXX.

267. In the tables the formula $S = \frac{50}{54} aB$ takes for $S = \frac{50}{54} \times$ *width* $\times$ *height*, and the tables are arranged a

	Heights.
Widths	$\frac{50}{54}$ *width* $\times$ *height*

The application to "Three-Level Sections" is as foll We have formula (162), p. 151,

$$A = \left(c + \frac{b}{2s}\right)\frac{D}{2} - \frac{b^2}{4s}$$

and for a prism 50 ft. in length ($l = 50$)

$$S = \frac{50}{27} A = \frac{50}{54}\left(c + \frac{b}{2s}\right)D - \frac{50}{54} \cdot \frac{b}{2s} \cdot b$$

or S is the sum of two quantities, each of which is i form for the use of the tables.

For cross-sections of a given base and slope (b an stants), $\frac{b}{2s}$ is a constant, and also $\frac{50}{54} \cdot \frac{b}{2s} \cdot b$ is const

We may then calculate once for all $\frac{b}{2s}$, and call th constant).

Also $\frac{50}{54} \cdot \frac{b}{2s} \cdot b$, and call this a constant E.

Then $$S = \frac{50}{54}(c + B)D - E$$

In using the tables, $c + B =$ height

$D =$ width

As in the previous tables, having found S_0 and S_1,

$$V_{100} = S_0 + S_1$$

and $$V_l = (S_0 + S_1)\frac{l}{100}$$

268. Example. Allen's Tables XXX.

Notes:—

Sta. 1	$\frac{9.1}{-2.4}$	-1.2	$\frac{7.3}{-1.2}$
Sta. 0	$\frac{8.8}{-2.2}$	-0.7	$\frac{6.4}{-0.6}$

$b = 11$ $\qquad$ $s = 1\frac{1}{2}$ to 1

$$\frac{b}{2s} = 3.7 = B$$

Grade triangle, $\frac{50}{54} \times 3.7 \times 11$

Under height 3.7, find

1 = 3.43	10. = 34.3
1 = 3.43	1. = 3.4
	E = 37.7

Station 1.

c = 1.2
B = 3.7
height = 4.9

$D = 9.1 + 7.3 = 16.4$

Under height 4.9, find

1 = 4.54	10. = 45.4
6 = 27.22	6. = 27.2
4 = 18.15	.4 = 1.8
	74.4
	E = 37.7
	S_1 = 36.7

Station 0.

c = 0.7
B = 3.7
height = 4.4

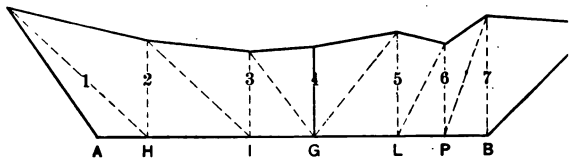
$D = 8.8 + 6.4 = 15.2$

Under height 4.4, find

1 = 4.07	10. = 40.7
5 = 20.37	5. = 20.4
2 = 8.15	.2 = 0.8
	61.9
	E = 37.7
	S_0 = 24.2

$V = S_1 + S_0 = 60.9$

269. Irregular Sections.



An "Irregular Section" can be divided into triangular p as in the figure. Taking generally two triangular parts toge for purposes of calculation, we have

$$A_1 = \frac{h_i \times (AG - d_H)}{2} \qquad s_1 = \frac{50}{54} h_i(AG - d_H)$$

$$A_2 = \frac{h_H \times (d_i - d_I)}{2} \qquad s_2 = \frac{50}{54} h_H(d_i - d_I)$$

$$A_3 = \frac{h_I \times (d_H - 0)}{2} \qquad s_3 = \frac{50}{54} h_I d_H$$

$$A_4 = \frac{c \times (d_I + d_L)}{2} \qquad s_4 = \frac{50}{54} c(d_I + d_L)$$

$$A_5 = \frac{h_L \times (d_P - 0)}{2} \qquad s_5 = \frac{50}{54} h_L d_P$$

$$A_6 = \frac{h_P \times (d_B - d_L)}{2} \qquad s_6 = \frac{50}{54} h_P(d_B - d_L)$$

$$A_7 = \frac{h_B \times (d_r - d_P)}{2} \qquad s_7 = \frac{50}{54} h_B(d_r - d_P)$$

$$S = s_1 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 \qquad (1$$

$$V_{100} = S_0 + S_1$$

$$V_l = (S_0 + S_1)\frac{l}{100}$$

The calculation of Irregular Sections in rough cour becomes very laborious unless the best methods are used, this process should be thoroughly understood.

CHAPTER XV.

EARTHWORK DIAGRAMS.

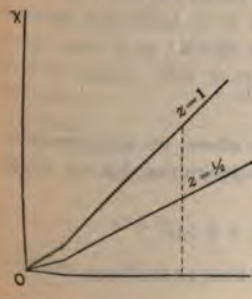
270. Computations of earthwork may also be made by means of diagrams from which results may be read by inspection merely.

The principle of their construction is explained as follows: — Given an equation containing three variable quantities as

$$x = zy \tag{194}$$

If we assume some value of z (making z a constant), the equation then becomes the equation of a right line.

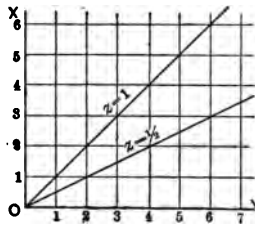
If this line be platted, using rectangular coördinates (as the line $z = 1$ in the figure), then having given any value of y, the corresponding value of x may be taken off by scale. If a new value of z be assumed, the equation is obtained of a new line which may also be platted (as $z = \frac{1}{2}$ in the figure), and from which also, having given any value of y, the corresponding value of x may be determined by scale. Assuming a series of values of z and platting, we have a series of lines, each representing a different value of z, and from any one of which, having given a value of y, we may by scale determine the value of x.



Thus, *given*, values of z and y; *required*, x, we may find,

1. The line corresponding to the given value of z, and
2. Upon this line we may find the value of x corresponding to the given value of y.

271. Next, if instead of platting upon *lines* as coördinate axes, we plat upon cross-section paper, the cross-section lines form a scale, so that the values of x and y need not be *scaled*, but may be *read* by simple inspection as in the figure.



272. If the equation be in the form

$$x = azy \qquad (195)$$

the same procedure is equally possible, and the line representing any value of z will still be a right line.

If the equation be in the form

$$x = a(z + b)(y + c) + d \qquad (196)$$

in which a, b, c, d, are constants, the same procedure is still possible, and the line representing a given value of z is a right line, as before.

The use of diagrams of this sort is therefore possible for the solution of equations in the form of

$$x = a(z + b)(y + c) + d$$

or in simpler modifications of this form.

273. Referring again to the figure above, we may consider the horizontal lines to represent successive values of x and refer to them as the lines

$$x = 0\,;\ x = 1\,;\ x = 2,\ \text{etc.}$$

and similarly we may refer to vertical lines as the lines

$$y = 0\,;\ y = 1\,;\ y = 2,\ \text{etc.}$$

just as we refer to the inclined lines

$$z = \tfrac{1}{2}\,;\ z = 1,\ \text{etc.}$$

Having given any two of the quantities x, y, z, the third may be found by inspection from the diagram by a process similar to that described.

274. Diagram for Prismoidal Correction.

Formula $$C = \frac{1}{3.24}(c_0 - c_1)(D_0 - D_1) \qquad (168)$$

This has the form $x = a \times z \times y$

Construction of diagram.

Assume (as we did for z) a series of values of

$$c_0 - c_1 = 0,\ 1,\ 2,\ 3,\ 4,\ 5, \text{ etc.}$$

When $c_0 - c_1 = 0$ then $C = 0$
or, the line $c_0 - c_1$ coincides with the line $C = 0$.

When $c_0 - c_1 = 1$, the equation of the line $c_0 - c_1$ is

$$C = \frac{1}{3.24}(D_0 - D_1)$$

To plat this right line, we must find two or more points on the line. For the reason that cross-section paper is generally warped somewhat, it is best to take a number of points not more than 3 or 4 inches apart, in order to get the lines sufficiently exact. For convenience, take values of $D_0 - D_1$ as follows:—

When $(c_0 - c_1) = 1$

take $D_0 - D_1 = 0,\ 3.24,\ 6.48,\ 9.72,\ 12.96,\ 16.20$, etc.

then $C = 0,\ 1,\ 2,\ 3,\ 4,\ 5$, etc.

When $c_0 - c_1 = 2$, the equation of the line $c_0 - c_1$ is

$$C = \frac{1}{3.24} \cdot 2(D_0 - D_1)$$

Therefore when $c_0 - c_1 = 2$

take $D_0 - D_1 = 0,\ 3.24,\ 6.48,\ 9.72,\ 12.96,\ 16.20$, etc.

then $C = 0,\ 2,\ 4,\ 6,\ 8,\ 10$, etc.

275. In like manner a table may be constructed.

	0	3.24	6.48	9.72	12.96	16.20	19.44	22.68	25.92	D_0
0	0	0	0	0	0	0	0	0	0	
1	0	1	2	3	4	5	6	7	8	
2	0	2	4	6	8	10	12	14	16	
3	0	3	6	9	12	15	18	21	24	
4	0	4	8	12	16	20	24	28	32	
5	0	5	10	15	20	25	30	35	40	
6	0	6	12	18	24	30	36	42	48	
7	0	7	14	21	28	35	42	49	56	
8	0	8	16	24	32	40	48	56	64	
9	0	9	18	27	36	45	54	63	72	
10	0	10	20	30	40	50	60	70	80	
$c_0 - c_1$										

276. It will be noticed that when $D_0 - D_1 = 0$, $C = 0$. Therefore for all values of $c_0 - c_1$, the lines pass through origin.

We may proceed to plat the lines $c_0 - c_1 = 1$, $c_0 - c_1 =$ $c_0 - c_1 = 3$, etc., from data shown in the above table, plat upon the lines $D_0 - D_1 = 3.24$, $D_0 - D_1 = 6.48$, etc., the po shown with circles around them in the cross-section sh p. 189.

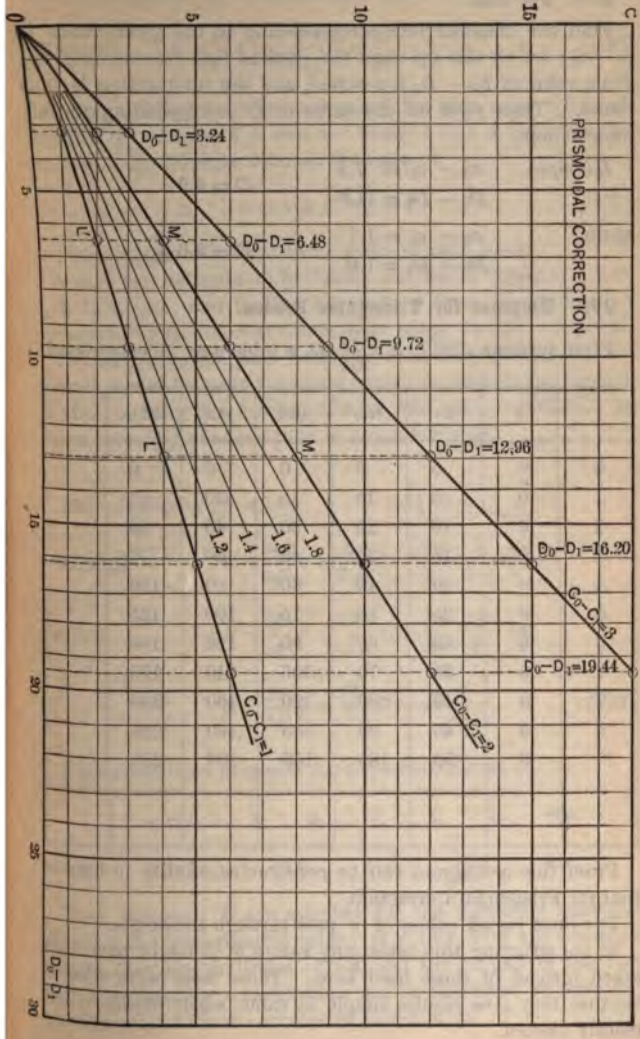
Having the lines $c_0 - c_1 = 1$, $c_0 - c_1 = 2$, 3, platted, in mediate lines are interpolated mechanically upon the p ciple that *vertical* lines would be proportionally divided ML is proportionally divided into 5 equal parts), and po are marked for the lines

$$c_0 - c_1 = 1.2, \quad 1.4, \quad 1.6, \quad 1.8$$

For the most convenient use, the values of $c_0 - c_1$ are ta o every second tenth of a foot in interpolating, as is show the diagram, p. 181, between 1 and 2; that is,

1.2, 1.4, 1.6, 1.8

A complete diagram is shown at the back of the book.


0
5
10
15
C
PRISMOIDAL CORRECTION
$D_0-D_1=3.24$
$D_0-D_1=6.48$
$D_0-D_1=9.72$
$D_0-D_1=12.96$
$D_0-D_1=16.20$
$D_0-D_1=19.44$
$C_0-C_1=3$
$C_0-C_1=2$
$C_0-C_1=1$
L
M
1.2
1.4
1.6
1.8
D_0-D_1

277. For Use.

Find the diagonal line corresponding to the given value of $c_0 - c_1$; follow this up until the vertical line representing the given value of $D_0 - D_1$ is reached, and the intersection is thus found. Then read off the value of C corresponding to this intersection.

Example. $c_0 - c_1 = 1.2$, $D_0 - D_1 = 11.0$ $\quad C = 4.0$

again, $c_0 - c_1 = 1.7$, $D_0 - D_1 = 7.0$ $\quad C = 3.6 \pm$

278. Diagram for Triangular Prisms.

From formula (191), $S = \frac{50}{54} cD$, a table may be constructed.

	0	5.4	10.8	16.2	21.6	27.0	D
0	0	0	0	0	0	0	
1	0	5	10	15	20	25	
2	0	10	20	30	40	50	
3	0	15	30	45	60	75	
4	0	20	40	60	80	100	
5	0	25	50	75	100	125	
6	0	30	60	90	120	150	
7	0	35	70	105	140	175	
8	0	40	80	120	160	200	
9	0	45	90	135	180	225	
10	0	50	100	150	200	250	
c							

From this a diagram can be constructed similar in form to that for Prismoidal Correction.

The lines for all values of c pass through the origin.

In constructing this table, any values of D might have been taken instead of those used here. Those used were selected because they give results simple in value, easily obtained, and readily platted.

279. Diagram for Three-Level Sections.

Formula, $$S = \frac{50}{54}\left(c + \frac{b}{2s}\right)D - \frac{50}{54} \cdot \frac{b}{2s} \cdot b \qquad (192)$$

A separate diagram will be required for each value (or combination of values) of b and s. Since b and s thus become constants, the formula assumes the form of

$$x = a(z + b)y + d \qquad (197)$$

and the diagram will consist of a series of right lines.

A table can be made up by taking successive values of $c = 0$, 1, 2, 3, 4, etc., and finding for each of these the value of S corresponding to different values of D, using the above formula.

To make separate and complete computations directly by formula would be quite laborious; there is, however, a method of systematizing the construction of the *table* which can be shown better by example than in any other way.

280. *Example.* $b = 14$ $\qquad s = 1\frac{1}{2}$ to 1

Formula $$S = \frac{50}{54}\left(c + \frac{b}{2s}\right)D - \frac{50}{54} \cdot \frac{b}{2s} \cdot b$$

becomes $$S = \frac{50}{54}\left(c + \frac{14}{3}\right)D - \frac{50}{54} \cdot \frac{14}{3} \cdot 14$$

$$S = \frac{50}{54}\left(c + \frac{14}{3}\right)D - 60.49 \qquad (198)$$

A table has been prepared for successive values of

$c = 0,$ 1, 2, 3, 4, 5, etc.

and for $D = 14,$ 16.2, 21.6, 27.0, etc.

These values of D are selected for the following reasons: $D = 14$ is the least possible value; $D = 16.2$, 21.6 are desirable because they are multiples of 5.4, and the factors in the formula show that the computations will be simplified by selecting multiples of 5.4 for the successive values of D.

	14	16.2	21.6	27.0	32.4	37.8	43.2	*D*
	12.963	15.	20.	25.	30.	35.	40.	Const. diff.
0	0	9.51	32.84	56.18	79.51	102.84	126.18	
1	12.963	24.51	52.84	81.18	109.51	137.84	166.18	
2	25.926	39.51	72.84	106.18	139.51	172.84	206.18	
3	38.889	54.51	92.84	131.18	169.51	207.84	246.18	
4	51.852	69.51	112.84	156.18	199.51	242.84	286.18	
5	64.815	84.51	132.84	181.18	229.51	277.84	326.18	
6	77.778	99.51	152.84	206.18	259.51	312.84	366.18	
7	90.741	114.51	172.84	231.18	289.51	347.84	406.18	
8	103.704	129.51	192.84	256.18	319.51	382.84	446.18	
9	116.667	144.51	212.84	281.18	349.51	417.84	486.18	
10	129.630	159.51	232.84	306.18	379.51	452.84	526.18	
c								

When $c = 0$ $\quad S = \frac{50}{54} \cdot \frac{14}{3} \cdot D - 60.49$

When $D = 14$ $\quad S = \frac{50}{54} \cdot \frac{14}{3} \cdot 14 - 60.49$

$= \quad 60.49 \quad - 60.49 = 0$

When $D = 16.2$

we may again calculate directly

$$S = \tfrac{50}{54} \cdot \tfrac{14}{3} \cdot 16.2 - 60.49$$

but a better method is to find how much greater S will be for $D = 16.2$ than for $D = 14.0$.

We have $\quad S = \frac{50}{54} \cdot \frac{14}{3} \cdot D - 60.49$

Then for any new value D'

$$S' = \tfrac{50}{54} \cdot \tfrac{14}{3} \cdot D' - 60.49$$

$$S' - S = \tfrac{50}{54} \cdot \tfrac{14}{3}(D' - D) \qquad (199)$$

for $\quad D' = 16.2 \quad D = 14.0 \quad D' - D = 2.2$

$$S' - S = \tfrac{50}{54} \cdot \tfrac{14}{3} \times 2.2 = 9.51$$

$$S = 0$$

$S' = 9.51$, which is entered in table.

Similarly, $S'' - S' = \frac{50}{54} \cdot \frac{14}{3}(D'' - D')$

$D'' = 21.6 \qquad D' = 16.2 \qquad D'' - D' = 5.4$

$S'' - S' = \frac{50}{54} \times \frac{14}{3} \times 5.4$

$= 23.333$

$S' = 9.51 \qquad S^{iv} = 79.509$

$S'' = 32.843 \qquad 23.333$

Similarly, $S''' - S'' = 23.333 \qquad S^{v} = 102.842$

$S''' = 56.176 \qquad 23.333$

$S^{iv} - S''' = 23.333 \qquad S^{vi} = 126.175$

$S^{iv} = 79.509$

Constant increment for $D' - D = 5.4$ is 23.333.

281. Each result is entered in the table in its proper place.

The final result for $c = 0$ and $D = 43.2$ should be calculated independently as a check.

When $c = 0 \qquad S = \frac{50}{54} \cdot \frac{14}{3} \cdot D \quad - 60.49$

When $D = 43.2 \qquad S = \frac{50}{54} \cdot \frac{14}{3} \times 43.2 - 60.49$

$= 50 \times \frac{14}{3} \times 0.8 - 60.49$

$= \frac{560}{3} \quad - 60.49$

$= 186.67 \quad - 60.49$

$S = 126.18$

This checks exactly, and all intermediate values are checked by this process, which is also more rapid than an independent calculation for each value of D.

282. We now have values of S for the various values of $D = 14.0,\ 16.2,\ 21.6$, etc., when $c = 0$.

Next, find how much these will be increased when $c = 1$.

Formula $\qquad S = \frac{50}{54}(c + \frac{14}{3})D - 60.49$

for any new value c' $\qquad S' = \frac{50}{54}(c' + \frac{14}{3})D - 60.49$

$$S' - S = \tfrac{50}{54}(c' - c)D \qquad (200)$$

When $c' = 1$ and $c = 0$, $\quad c' - c = 1$

$$S' - S = \tfrac{50}{54} D$$

Similarly, $\quad S'' - S' = \tfrac{50}{54}(c'' - c')D$

When $c'' = 2$ and $c' = 1$, $\quad c'' - c' = 1$

$$S'' - S' = \tfrac{50}{54} D$$

That is, for *any increase* of 1 ft. in the value of c,

$$S' - S = \tfrac{50}{54} D \qquad (201)$$

When $D = 14$

$$S' - S = \tfrac{50}{54} \times 14 = 12.963$$

This we enter as the constant difference for column $D = 14$.

We have already found

$S_0 = 0$

12.963

$S_1 = 12.963$

12.963

$S_2 = 25.926$

This gives column 14. $\quad S_3 = 38.889$ etc.

When $D = 16.2$

(201) $\quad S' - S = \tfrac{50}{54} D = \tfrac{50}{54} \times 16.2 = 50 \times 0.3$

$= 15$

Enter 15 as the constant difference in column 16.2.

We already have

$S_0 = 9.51$

$15.$

$S_1 = 24.51$

$15.$

$S_2 = 39.51$

This allows us to complete column 16.2. $\quad S_3 = 54.51$ etc.

Similarly for $\quad D = 21.6 \qquad S' - S = 20$

Enter 20 as constant difference in column 21.6, and complete column as shown in table.

Similarly, fill out all the columns shown in the table.

. The final result for $c = 10$, $D = 43.2$ should be calcu- ndependently, and directly from the formula, as a check.

$$S = \tfrac{50}{54}(c + \tfrac{1}{3}^4)D \qquad - 60.49$$
$$c = 10 \qquad D = 43.2$$
$$S = \tfrac{50}{54} \times 14.667 \times 43.2 - 60.49$$
$$= 50 \times 14.667 \times 0.8 - 60.49$$
$$= 40 \times 14.667 \qquad - 60.49$$
$$= 586.68 \qquad - 60.49$$
$$S = 526.19$$

e table gives 526.18. This checks sufficiently close to indi- that no error has been made. It would yield an exact if we took $c + \frac{1}{3}^4 = 14.6667$.

4. Note that for $c = 10$ $D = 43.2$ value = 526.18
$c = 10$ $D = 37.8$ " 452.84
Diff. = 73.34

tween $c = 10$ $D = 37.8$ } Diff. = 73.33
$c = 10$ $D = 32.4$ }

line $c = 10$ a constant difference is found between succes- values of D differing by 5.4. This may be demonstrated = 73.33.

values in the table except column 14 are satisfactorily ted by applying this difference of 73.33 in line 10 together the independent check of $c = 10$, $D = 43.2$.

e value of $c = 10$, $D = 14$ can also be checked and shown correct.

5. Having the table, page 192, completed, the construction e diagram is simple.

e "*Diagram for Three-Level Sections, Base* 14, *Slope* $1\frac{1}{2}$ " was calculated and constructed according to this table. Diagram given shows a general arrangement of lines and es convenient for use. For rapid and convenient use, the am should be constructed upon cross-section paper, Plate nd in this case the diagram will be upon a scale twice that e diagram accompanying these notes.

A "curve of level section" has been platted on this diagram in the following manner. For level sections, when

$c = 0$	$D = 14.0$	$c = 2$	$D = 20.0$
$c = 1$	$D = 17.0$	$c = 6$	$D = 32.0$
$c = 1.4$	$D = 18.2$ etc.		

The line passing through these points gives the "curve of level section."

Aside from the direct use of this curve of level section (for preliminary estimates or otherwise), it is very useful in tending to prevent any gross errors in the use of the table, since, in general, the points (intersections) used in the diagram will lie not far from the curve of level section.

286. Use of Diagram.

Find the diagonal line corresponding to the given value of c; follow this up until the vertical line representing the given value of D is reached, and this intersection found. Then read off the value of S corresponding to this intersection.

Example. Notes.

Sta. 1	$\frac{16.0}{-6.0}$	-3.7	$\frac{12.4}{-3.6}$	$S_1 = 160.$
Sta. 0	$\frac{10.6}{-2.4}$	-2.5	$\frac{10.3}{-2.2}$	$S_0 = 78.$
				$V = 238.$

For Sta. 1 $c = 3.7$ $D = 25.4$

$c = 3.7$ is the middle of the space between 3.6 and 3.8.

Follow this up until the vertical line 28.4 is reached.

The intersection lies upon the line $S_1 = 160$.

Enter this above opposite Sta. 1.

For Sta. 0 $c = 2.5$ $D = 20.9$

$c = 2.5$ is the middle of space between 2.4 and 2.6.

Follow this up until the middle of space between 20.8 and 21.0 is reached.

The intersection lies just above the line

$$S_0 = 78$$

Enter this opposite Sta. 0.

$$V_{100} = S_1 + S_0$$
$$= 160 + 78 = 238 \text{ cu. yds.}$$

The prismoidal correction may be applied if desired.

287. Diagrams may be constructed in this way that will give results to a greater degree of precision than is warranted by the precision reached in taking the measurements on the ground.

In point of rapidity *diagrams are much more rapid than tables* for the computation of *Three-Level Sections.*

For "*Triangular Prisms*" and for *Prismoidal Correction*, the *diagrams* are *somewhat more rapid.*

For *Level Sections*, the tables for Three-Level Sections are *at least equally rapid.*

288. The use of approximate methods for applying the prismoidal correction to irregular sections will now be rendered very practicable by the use of these "Diagrams for Three-Level Sections."

Method 1. No use of diagrams is necessary.

Method 2. Having found for any irregular sections (by triangular prisms or any other method) the solidity S for 50 ft. in length, find upon the diagram the line corresponding to this value of S; follow this line to the curve of level section, and read off the value of c (for a level section) which corresponds, and also the value of D for the same section.

Method 3. Having found in any way the value of S; if c is given, find the value of D to correspond; if D is given, find the value of c to correspond.

Method 4. The use of diagrams is not needed.

The diagrams shown at the back of the book are given partly to show a good scheme or arrangement, and partly to allow practice in their use. For regular work the scale is too small to be desirable, and trying to the eyes. They are not sufficiently extensive. In offices where there is much earthwork computation to be done, diagrams should be constructed on double the scale and extending to higher numbers. Several sheets may be required for each kind of diagram. It may seem that sufficiently precise values cannot be read from these diagrams, but the diagrams are much more precise than the field-work, where a center cut is not sure to one tenth of a *foot.*

CHAPTER XVI.

HAUL.

289. When material from excavation is hauled to be plac in embankment, it is customary to pay to the contractor certain sum for every cubic yard hauled. Oftentimes it is pr vided that no payment shall be made for material hauled l than a specified distance. In the east a common limit of "fr haul" is 1000 ft. Often in the west 500 ft. is the limit "free haul." Sometimes 100 ft. is the limit.

A common custom is to make the unit for payment of ha one yard hauled 100 ft.; the price paid will often be from 1 2 cents per cubic yard hauled 100 ft.

The price paid for "haul" is small, and therefore the stan ard of precision in calculation need not be quite as fine as the calculation of the quantities of earthwork. The to "haul" will be the product of

(1) the total amount of excavation hauled, and

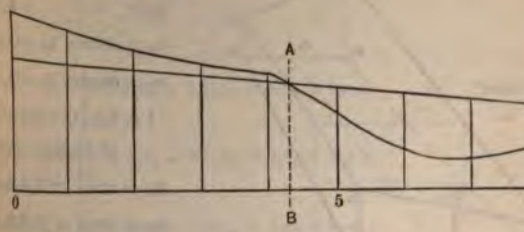
(2) the average length of haul.

290. The average length of haul is the distance between t center of gravity of the material as found in excavation, a the center of gravity as deposited. It would not, in general, simple to find the center of gravity of the entire mass of ex vation hauled, and the most convenient way is to take ea section of earthwork by itself. The "haul" for each secti is the product of the

(1) number of cubic yards in that section, and

(2) distance between the center of gravity in excavatic and the center of gravity as deposited.

291. When excavation is placed in embankment, there may be some difficulty in determining just where any given section of excavation will be placed, and where its center of gravity will be in embankment.



In hauling excavation in embankment, there is some plane, as indicated by AB, *to* which all excavation must be hauled on its way to be placed in embankment, and (another way of putting it) *from* which all material placed in embankment must be hauled on its way from excavation. We may figure the total haul as the sum of

(1) total "haul" of excavation *to* AB, and

(2) total "haul" of embankment *from* AB.

The total "haul" of excavation *to* AB and the total "haul" of embankment *from* AB will most conveniently be calculated as the sum of the hauls of the several sections of earthwork. For each section the haul is the product of

(1) the volume V of that section, and

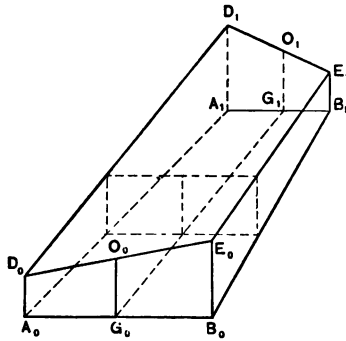
(2) distance from center of gravity of that section to the plane AB.

292. When the two end areas are equal, the center of gravity will be midway between the two end planes. When the two end areas are not equal in value, the center of gravity of the section will be at a certain distance from the mid-section, as shown by the formula

$$x_g = \frac{l^2}{12} \cdot \frac{A_1 - A_0}{V}$$

In which x_g = distance of center of gravity from mid-section.

293. Referring to the figure below, and following the same general method of demonstration used previously, § 235,



let b_0 = base = A_0B_0

b_1 = " = A_1B_1

c_0 = center ht. = O_0G_0

c_1 = center ht. = O_1G_1

l = length (altitude) of section = G_0G_1

A_0 = area of $D_0A_0B_0E_0$

A_1 = area of $D_1A_1B_1E_1$

V = volume

Also use notation b_x, c_x, A_x for a section distant x from G_1.

Find the distance of the center of gravity from $A_1B_1E_1D_1$, and let this $= x_c$. Let x_g = distance of center of gravity from mid-section.

Then for any elementary section of thickness dx and distance x from $A_1B_1E_1D_1$, its moment will be

$$\left[b_1 + (b_0 - b_1)\frac{x}{l}\right]\left[c_1 + (c_0 - c_1)\frac{x}{l}\right] x\,dx$$

$$V \cdot x_c = \int_0^l \left[b_1 + (b_0 - b_1)\frac{x}{l}\right]\left[c_1 + (c_0 - c_1)\frac{x}{l}\right] x\,dx$$

$$V \cdot x_c = \frac{b_1c_1l^2}{2} + \frac{b_1(c_0-c_1)l^3}{3\,l} + \frac{c_1(b_0-b_1)l^3}{3\,l} + \frac{(c_0-c_1)(b_0-b_1)l^4}{4\,l^2}$$

$$= \frac{l^2}{12}\begin{bmatrix} 6\,b_1c_1 + 4\,b_1c_0 + 4\,b_0c_1 + 3\,b_0c_0 \\ -4\,b_1c_1 - 3\,b_1c_0 - 3\,b_0c_1 \\ -4\,b_1c_1 \\ +3\,b_1c_1 \end{bmatrix}$$

$$V \cdot x_c = \frac{l^2}{12} \times (b_1c_1 + b_1c_0 + b_0c_1 + 3\,b_0c_0)$$

$$x_c = \frac{l^2}{12} \times \frac{b_1c_1 + b_1c_0 + b_0c_1 + 3\,b_0c_0}{V} \qquad (202)$$

What is wanted is x_g rather than x_c.

$$x_g = \frac{l}{2} - x_c$$

$$Vx_g = V\frac{l}{2} - Vx_c$$

$$V = \frac{l}{6}(2\,b_1c_1 + 2\,b_0c_0 + b_1c_0 + b_0c_1) \qquad \text{from (164)}$$

$$V \cdot \frac{l}{2} = \frac{l^2}{12}(2\,b_1c_1 + 2\,b_0c_0 + b_1c_0 + b_0c_1) \qquad (203)$$

$$V \cdot x_c = \frac{l^2}{12}\ (b_1c_1 + 3\,b_0c_0 + b_1c_0 + b_0c_1)$$

$$V \cdot x_g = \frac{l^2}{12}\ (b_1c_1 - b_0c_0)$$

$$= \frac{l^2}{12}\ (A_1 - A_0)$$

$$x_g = \frac{l^2}{12}\ \frac{A_1 - A_0}{V} \quad (V \text{ in cu. ft.}) \qquad (204)$$

$$x_g = \frac{l^2}{12 \times 27} \cdot \frac{A_1 - A_0}{V} \quad (V \text{ in cu. yds.}) \qquad (205)$$

294. The formula above applies to the solid shown in the figure, which has trapezoidal ends, but it will apply also when D_0A_0, D_1A_1 are each $= 0$, and therefore applies to such solids having triangular ends; and since any section of earthwork with parallel ends may be divided into a number of such solids with triangular ends, it applies to all ordinary sections of railroad earthwork, since it applies to the parts of which it is made up.

To show that in fact this formula is correct for prisms, wedges, and pyramids, use a method similar to that shown on page 155; find for each solid an expression for x_g in terms of A and l; reduce to the form

$$x_g = \frac{l^2}{12} \cdot \frac{A_1 - A_0}{V}$$

295. The formula

$$x_{\varrho} = \frac{l^2}{12 \times 27} \cdot \frac{A_1 - A_0}{V}$$

is not in form convenient for use, because we have not f the values of A_1 and A_0, but instead have calculated dir from the tables or diagrams the values of S_1 and S_0 for 5 in length, where

$$S_1 = \frac{50}{27} A_1, \text{ or } A_1 = \frac{27\, S_1}{50}$$

and

$$A_0 = \frac{27}{50} S_0$$

Substituting,

$$x_{\varrho_{100}} = \frac{100 \times 100}{12 \times 27} \cdot \frac{S_1 - S_0}{V} \cdot \frac{27}{50}$$

$$x_{\varrho_{100}} = \frac{100}{6} \cdot \frac{S_1 - S_0}{V} \qquad (1)$$

where V is the correct volume in cu. yds.

This formula is in shape convenient for use, and re correct to the nearest foot can be calculated with rapidity.

296. For a section of length l less than 100 ft.

$$x_{\varrho_l} = \frac{l^2}{12 \times 27} \cdot \frac{A_1 - A_0}{V_l}$$

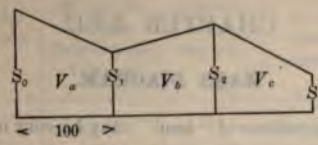
$$= \frac{l^2}{12 \times 27} \cdot \frac{A_1 - A_0}{V_{100} \times \frac{l}{100}}$$

$$= \frac{100\, l}{12 \times 27} \cdot \frac{A_1 - A_0}{V_{100}}$$

$$x_{\varrho_{100}} = \frac{100 \times 100}{12 \times 27} \cdot \frac{A_1 - A_0}{V_{100}}$$

$$x_{\varrho_l} = x_{\varrho_{100}} \cdot \frac{l}{100} \qquad (2)$$

297. For a *series of sections*, each 100 ft., a correction may be applied to obtain the correction in haul for the entire mass.



Let X_c = cent. of grav. for entire mass (approximately),

found by using for each section *c.g.* at $\frac{l}{2}$

H_a = approx. total haul $= V \times X_c$

X = true dist. to *c.g.* of entire mass

H = correct total haul $= V \times X$

$S_0 = \frac{5}{2}\frac{0}{7} A_0$, $S_1 = \frac{5}{2}\frac{0}{7} A_1$, $S_2 =$ etc., as taken from tables or diagrams.

When all sections are of uniform length, 100′ as in figure above, approximate total haul

$$H_a = X_c V = \frac{100}{2}(V_a + 3\,V_b + 5\,V_c)$$

Correct total haul

$$H = XV = V_a\left(\frac{100}{2} + x_{ga}\right) + V_b\left(3\frac{100}{2} + x_{gb}\right) + V_c\left(5\frac{100}{2} + x_{gc}\right)$$

$$H - H_a = V_a x_{ga} + V_b x_{gb} + V_c x_{gc}$$

$$= \frac{100}{6}\left[V_a \frac{S_0 - S_1}{V_a} + V_b \frac{S_1 - S_2}{V_b} + V_c \frac{S_2 - S_3}{V_c}\right]$$

$$= \frac{100}{6}(S_0 - S_3)$$

Or for a more general form

$$H - H_a = \frac{100}{6}(S_0 - S_n) = \text{correction in total haul.} \qquad (208)$$

This should be in cu. yds. hauled 100 ft.

CHAPTER XVII.

MASS DIAGRAM.

298. Many questions of "haul" may be very usefully treated by means of a graphical method which will be designated the "Mass Diagram."

The construction of the "Mass Diagram" will be more clearly understood from an example than from a general description.

Let us consider the earthwork shown by the profile on p. 206, consisting of alternate "cut" and "fill." To show the work of constructing the "diagram" in full, the quantities are calculated throughout, but for convenience and simplicity, "level sections" are used and prismoidal correction disregarded. In a case in actual practice, the solidities will have been calculated for the actual notes taken. Allowance should be made for the fact that earth placed in fill shrinks or occupies less space than in its original form. In the table, next page, a shrinkage of 5 per cent is assumed.

299. In the table, p. 205, the

1st column gives the station; 2d column gives center heights.

3d column gives values of S from tables.

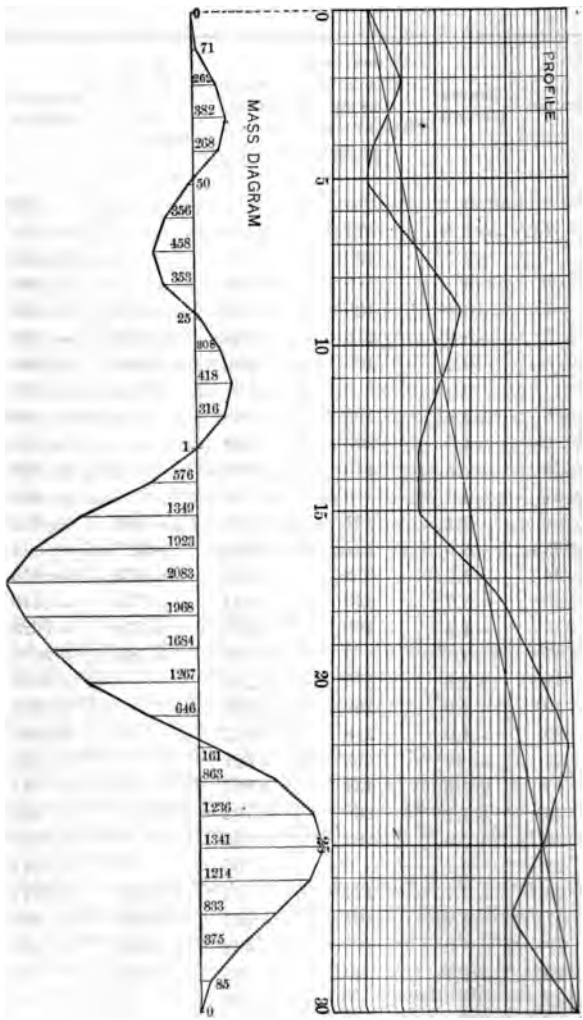
4th column gives values of S_{100} or S_l for each section, and with sign + for cut or − for fill.

5th column shows fills after 5 per cent shrinkage.

6th column gives the total, or the sum of solidities up to each station; and in getting this total, each + solidity is added and each − solidity is subtracted, as appears in the table from the results obtained.

Having completed the table, the next step is the construction of the "Mass Diagram," page 206. In the figure shown there, each station line is projected down, and the value from column 6, corresponding to each station, is platted to scale as an offset from the base line at that station, all + quantities above the line, and all − quantities below the line. The points thus found are joined, and the result is the "Mass Diagram."

Station.	Center Heights.	Solidity for 50′ due to Center Height (from Tables).	Solidity for Section.	Fills −5 Per Cent Shrinkage	Solidity Totals.
0	0	0			0
1	+1.7	71	+ 71		+ 71
2	+2.7	120	+191		+ 262
3	0	0	+120		+ 382
4	−3.4	120	−120	−114	+ 268
5	−5.3	215	−335	−318	− 50
6	−3.1	107	−322	−306	− 356
7	0	0	−107	−102	− 458
8	+2.4	105	+105		− 353
9	+4.5	223	+328		− 25
10	+2.5	110	+333		+ 308
11	0	0	+110		+ 418
12	−3.1	107	−107	−102	+ 316
13	−5.5	227	−334	−317	− 1
14	−7.9	378	−605	−575	− 576
15	−8.7	436	−814	−773	−1349
16	−4.4	168	−604	−574	−1923
17	0	0	−168	−160	−2083
18	+2.6	115	+115		−1968
19	+3.6	169	+284		−1684
20	+4.9	248	+417		−1267
21	+6.7	373	+621		− 646
22	+7.5	434	+807		+ 161
23	+5.2	268	+702		+ 863
24	+2.4	105	+373		+1236
25	0	0	+105		+1341
26	−3.7	134	−134	−127	+1214
27	−6.2	267	−401	−381	+ 833
28	−5.3	215	−482	−458	+ 375
29	−2.7	90	−305	−290	+ 85
30	0	0	− 90	− 85	0


MASS DIAGRAM
PROFILE
0
71
262
382
268
50
356
458
353
25
308
418
316
1
576
1349
1923
2083
1968
1684
1267
646
161
863
1236
1341
1214
833
375
85
0
0
5
10
15
20
25
30

300. It will follow, from the methods of calculation and construction used, that the "Mass Diagram" will have the following properties, which can be understood by reference to the profile and diagram, page 206.

1. Grade points of the profile correspond to maximum and minimum points of the diagram.

2. In the diagram, ascending lines mark excavation, and descending lines embankment.

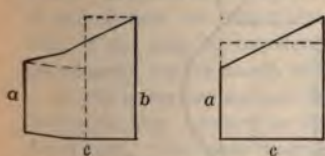
3. The difference in length between any two vertical ordinates of the diagram is the solidity between the points (stations) at which the ordinates are erected.

4. Between any two points where the diagram is intersected by any horizontal line, excavation equals embankment.

5. The area cut off by any horizontal line is the measure of the "haul" between the two points cut by that line.

301. It may be necessary to explain the latter point at somewhat greater length.

Any quantity (such as dimension, weight, or volume) is often represented graphically by a line; in a similar way, the product of two quantities (such as volume into distance, or as foot pounds) may be represented or measured by an area. In the case of a figure other than a rectangle, the value, or product measured by this area, may be found by cutting up the area by lines, and these lines may be vertical lines representing volumes or horizontal lines representing distance. The result will be the same in either case. An example will illustrate.



In the two figures let

a and b represent pounds

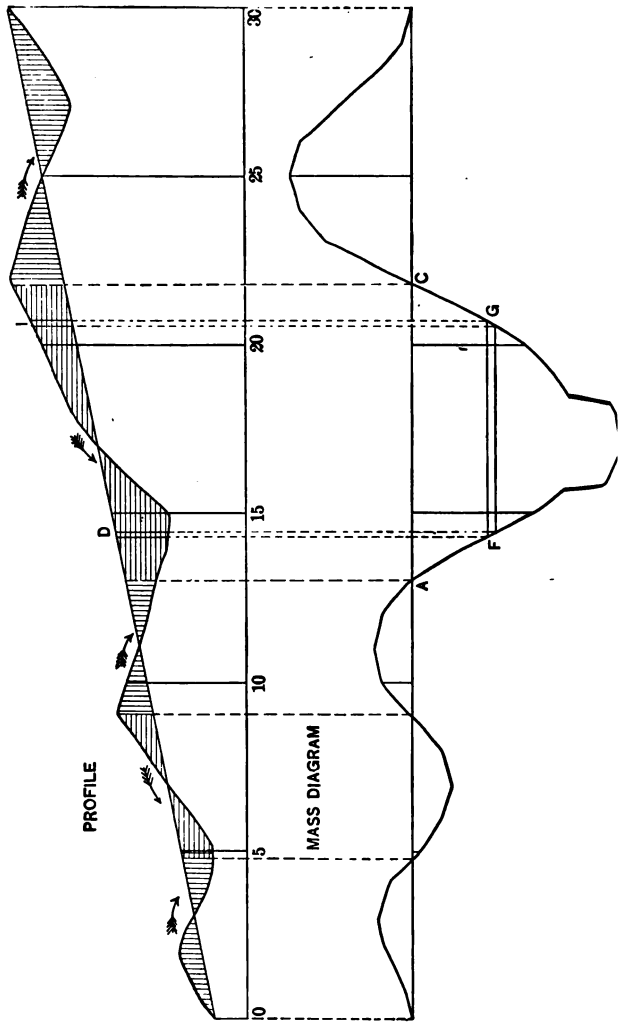
c " feet

and the area of the trapezoid represent a certain number of foot pounds. The trapezoid may be resolved into rectangles by the use of a vertical line, as shown in Fig. 1, or by a horizontal line, as in Fig. 2.

In Fig. 1, the area is $a \times \frac{c}{2} + b \times \frac{c}{2}$

In Fig. 2, the area is $\frac{a+b}{2} \times c$

the result of course being the same in both cases.


PROFILE
MASS DIAGRAM
0
5
10
15
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25
30
A
C
D
F
G

302. In an entirely similar way, the area ABC (p. 208) represents the "haul" of earthwork (in cu. yds. moved 100 ft.) between A and C, and this area may be calculated by dividing it by a series of vertical lines representing solidities, as shown above G and F. That this area represents the haul between A and C may be shown as follows:—

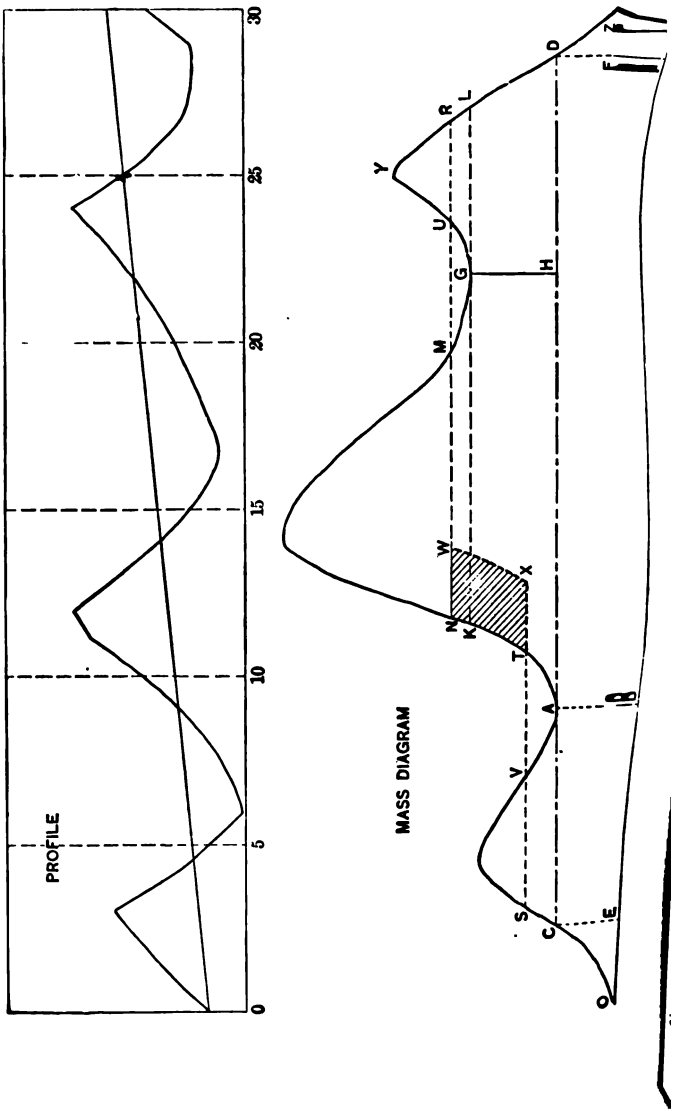
Take any elementary solidity dS at D. Project this down upon the diagram at F, and draw the horizontal lines FG.

Between the points F and G (or between D and I), therefore, excavation equals embankment, and the mass dS must be hauled a distance FG, and the amount of "haul" on dS will be $dS \times$ FG, measured by the trapezoid FG. Similarly with any other elementary dS.

The total "haul" between A and C will be measured by the sum of the series of trapezoids, or by the area ABC. This area is probably most conveniently measured by the trapezoids formed by the vertical lines representing solidities. The average length of haul will be this area divided by the total solidity (represented in this case on p. 206 by the longest vertical line, 2083).

303. The construction of the "Mass Diagram" as a series of trapezoids involves the assumption that the center of gravity of a section of earthwork lies at its mid-section, which is only approximately correct since S for the first 50 ft. will seldom be exactly the same as S for the second 50 ft. of a section 100 ft. long. If the lines joining the ends of the vertical lines be made a curved line, the assumption becomes more closely accurate, and if the area be calculated by "Simpson's Rule," or by planimeter, results closely accurate will be reached.

It will be further noticed that hill sections in the "diagram" represent haul forward on the profile, and valley sections haul backward. The mass diagram may therefore be used to indicate the methods by which the work shall be performed; whether excavation at any point shall be hauled forward or backward; and, more particularly, to show the point where backward haul shall cease and forward haul begin, as indicated in the figure, p. 208, which shows a very simple case, the cuts and fills being evenly balanced, and no haul over 900 feet, with no necessity for either borrowing or wasting.


PROFILE
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MASS DIAGRAM
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S
C
E
O
B
D
F

304. In the figure, page 210, the excavation from Sta. 0 to 14 is very much in excess of embankment, and *vice versa* from Sta. 14 to 30. The mass diagram indicates a haul of nearly 3000 ft. for a large mass of earthwork, measured by the ordinate AB. It will not be economical to haul the material 3000 ft.; it is better to "waste" some of the material near Sta. 0, and to "borrow" some near Sta. 30, if this be possible, as is commonly the case.

If we draw the line CD, the cut and fill between C and D will still be equal, and the volume of cut measured by CE can be wasted, and the equal volume of fill measured by DF can be borrowed to advantage. It can be seen that there is still a haul of nearly 2000 ft. (from A to D) on the large mass of earthwork measured by GH. It is probable that it will not pay to haul the mass GH, or any part of it, as far as AD.

305. We must find the limit beyond which it is unprofitable to *haul* material rather than *borrow* and *waste*.

Let c = cost of 1 cu. yd. excavation or embankment.
h = cost of haul on 1 cu. yd. hauled 100 ft.
n = length of haul in "stations" of 100 ft. each.

Then, when 1 cu. yd. of excavation is wasted, and 1 cu. yd. of embankment is borrowed,

$$\text{cost} = 2c$$

When 1 cu. yd. of excavation is hauled into embankment,

$$\text{cost} = c + nh$$

The limit of profitable haul is reached when

$$2c = c + nh$$

or when

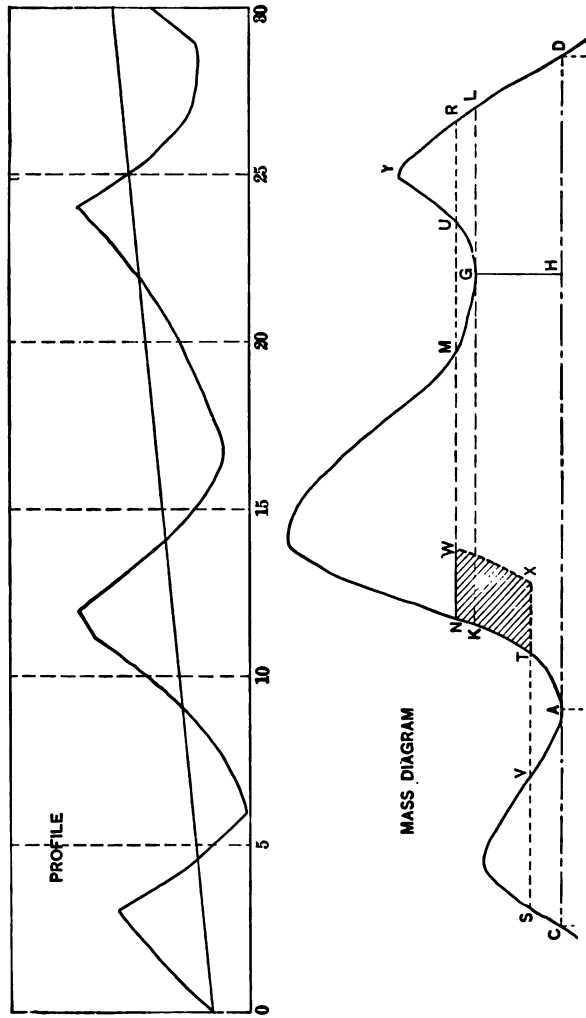
$$n = \frac{c}{h} \qquad (209)$$

Example. When excavation or embankment is 18 cents per cu. yd., and haul is $1\frac{1}{2}$ cents,

$$n = \frac{18}{1.5} = 12 \text{ stations}$$

When $c = 16$ and $h = 2$

then $n = 8$ stations


PROFILE
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MASS DIAGRAM
C
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V
A
T
K
N
W
X
M
G
U
Y
R
L
H
D

306. In the former case (1200 ft. haul) we should draw in mass diagram (p. 212) the line KGL. Here KG is less than 1200 ft. The line should not be lower than G, for in that case the haul would be nearly as great as KL, or more than 1200 ft.

In the latter case (800 ft. haul) the line would be carried up to a point where NM = 800 ft. The masses between N and A, also C and O, can better be wasted than hauled, and the masses between M and G, also L and Z, can better be borrowed than hauled (always provided that there are suitable places at hand for borrowing and wasting).

Next, produce NM to R. The number of yards borrowed will be the same whether taken at RZ or at MG + LZ. That arrangement of work which gives the smallest "haul" (product of cu. yds. × distance hauled) is the best arrangement. The "haul" in one case is measured by GLRYU, and in the other by MGU + UYR. If MGU is less than GLRU, then it is cheaper to borrow (*a*) RZ rather than (*b*) MG + LZ.

In a similar way material NT and SO can be wasted more economically than NA and CO.

The most economical position for the line MR is when MU=UR. For ST, when SV = VT. For any change from these positions of MR and ST will show an increase of area representing "haul."

307. The case is often not as simple as that here given. Very often the material borrowed or wasted has to be hauled beyond the limit of "free haul." The limit beyond which it is unprofitable to haul will vary according to the length of haul on the borrowed or wasted material; the limit will, in general, be increased by the length of haul on the borrowed or wasted material. The haul on wasted or borrowed material, as NT, may be shown graphically by NTXW, where NW = TX shows the length of haul, and NTXW the "haul" (mass × distance).

The mass diagram can be used also for finding the limit of "free haul" on the profile, and various applications will suggest themselves to those who become familiar with its use and the principles of its construction. Certainly one of its most important uses is in allowing "haul" and "borrow and waste" to be studied by a diagram giving a comprehensive view of the whole situation. There are few if any other available methods of accomplishing this result.

308. When material is first taken out in excavation, it generally occupies more space than was originally the case. When placed in embankment, it commonly shrinks somewhat and eventually occupies less space than originally. Wherever, from any cause, the material put into embankment will occupy more space or less space than it did in excavation, the quantities in embankment should be corrected before figuring haul or constructing a Mass Diagram, and a column should be shown for this as is done in Table p. 205.

309. Many engineers write their contracts and specifications without a clause allowing payment for "haul" or "overhaul." Nevertheless it appears that it is the more common practice to insert a clause providing for payment for overhaul. A canvass on this subject by the American Railway Engineering and Maintenance of Way Association in 1905 showed this practice to prevail in the proportion of 73 to 37. The free haul limit of 500 ft. seemed to meet with greater favor than any other.

Where an "overhaul" clause is inserted in a contract, the basis of payment has varied on different railroads. In one method, not recommended, the total haul is to be computed; from this shall be deducted for free haul the total "yardage" multiplied by the length of the free haul limit. Under this system, with a 500 ft. free haul limit, there might be 10,000 cu. yds. of earth hauled (all of it) more than 500 ft., or an average of 600 ft.; yet if there were another 10,000 cu. yds. hauled an average of 300 ft., there would be no payment whatever for overhaul; the average haul would be less than 500 ft. Unless the specifications clearly show that this method is to be used, it is unfair as well as unsatisfactory to the contractor.

What seems a logical and satisfactory provision is that recommended by the American Railway Engineering and Maintenance of Way Association by a letter ballot vote of 134 to 23 (announced in March, 1907). This is as follows: —

"No payment will be made for hauling material when the length of haul does not exceed the limit of free haul, which shall be _____ feet.

"The limits of free haul shall be determined by fixing on the profile two points, one on each side of the neutral grade point, *one in excavation* and the other in embankment, such that the *distance between* them equals the specified free haul limit, and

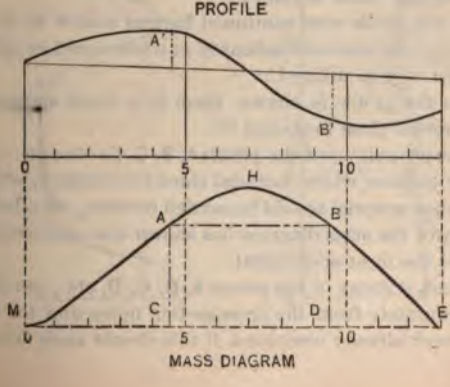
the included quantities of excavation and embankment balance. All haul on material beyond this free haul limit will be estimated and paid for on the basis of the following method of computation, viz.: —

"All material within this limit of free haul will be eliminated from further consideration.

"The distance between the center of gravity of the remaining mass of excavation and center of gravity of the resulting embankment, less the limit of free haul as above described, shall be the length of overhaul, and the compensation to be rendered therefor will be determined by multiplying the yardage of the remaining mass as above described, by the length of the overhaul. Payment for the same will be by units of one cubic yard hauled one hundred feet.

"When material is obtained from borrow-pits along the embankment, and runways are constructed, the haul shall be determined by the distance the team necessarily travels. The overhaul on material thus hauled shall be determined by multiplying the yardage so hauled by one half the round distance made by the team less the free haul distance. The runways will be established by the engineer."

310. This statement as to the method of figuring overhaul is explained very simply by the Mass Diagram below. The length of AB is that of the free haul limit (500 ft. in figure). The free haul is shown in the area ACDBHA. The amount of overhaul to be paid for is shown in 2 parts, ACM, BDE.



MASS DIAGRAM

311. The diagram on the page opposite shows a sketch
profile and the corresponding mass diagram ; illustrating fur
the method of studying questions of haul, borrow, and wa
For this purpose it is assumed that the limit of economical
is 1000 ft., and the lines on the mass diagram are adjusted
cordingly.

(*a*) Line AB = 1000 ft. and can go no lower because the l
of 1000 ft. would be exceeded ; nor higher because the w
near A and the borrow near B would be increased.

(*b*) Line CDE is placed so that CD = DE ; the sum of the
borrows (between B and C, and between E and F) is the s
for any practical position of CDE ; the sum of the two a
CRD and DSE is a minimum when CD = DE.

(*c*) Line FG = 1000 ft. and can go no higher without exceed
1000 ft. nor lower without increasing borrow near F and w
near G.

(*d*) Line HJ can go no lower without exceeding 1000 ft.
higher without increasing waste near H and borrow near J.

(*e*) Line JKLM can go no higher because the borrow betw
M and N would be increased. The area above JK and LM c
be decreased materially, and the area below KL increased
slightly, by moving JKLM higher, but the loss due to the
creased amount of borrow between M and N would far exc
the gain in the haul item.

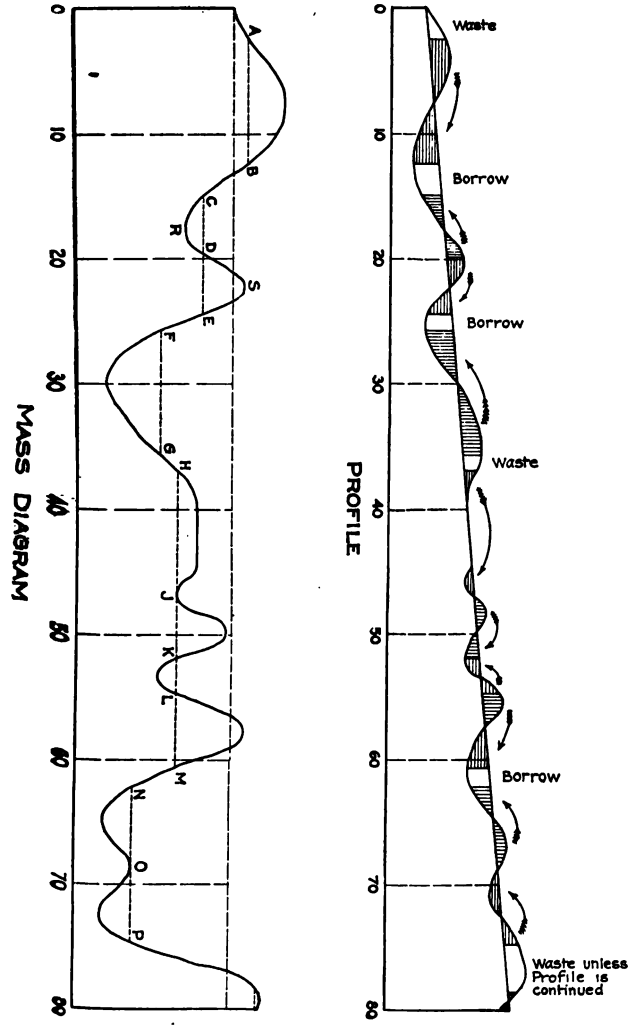
(*f*) Line NOP can go no higher without exceeding 1000 ft.
can go no lower without increasing the borrow between M
N, and also the waste beyond P.

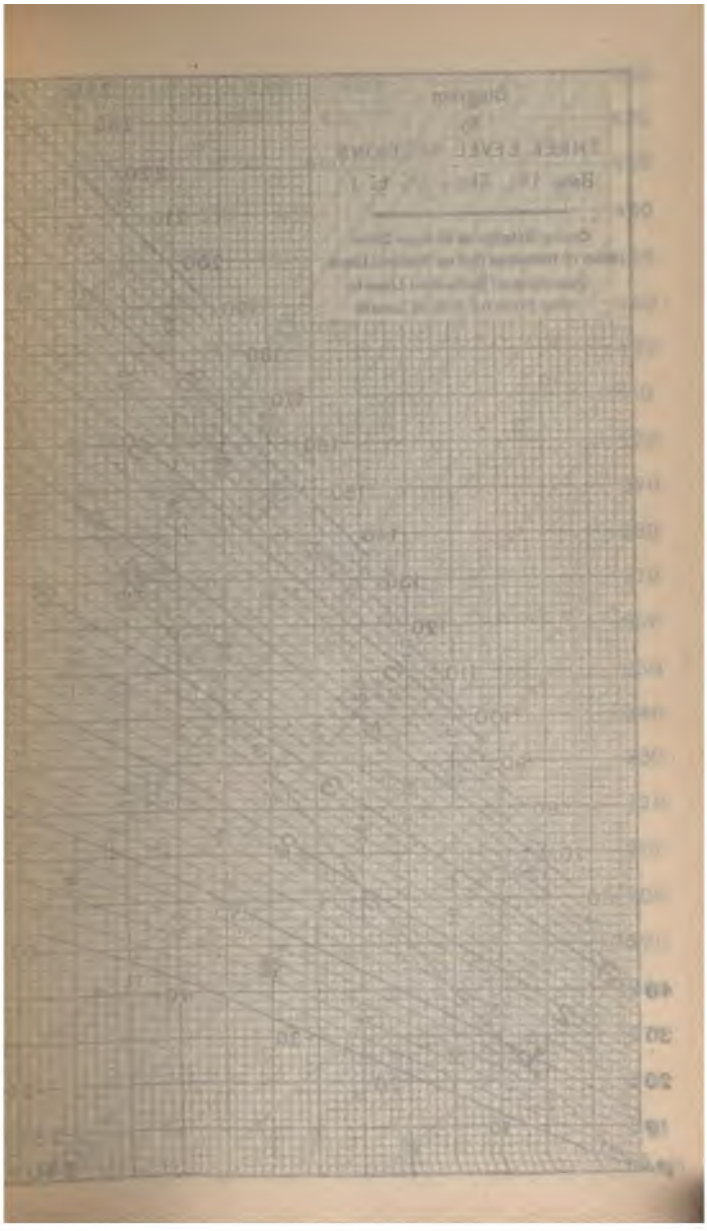
(*g*) If the profile were continued beyond station 80, it is q
possible that the material indicated as waste could be utilize
fill, or part of it so utilized.

(*h*) As the profile is shown, there is a small amount of
carried into fill close to station 80.

(*i*) The projections of the points A, B, C, D, etc., up to the
file, serve to show where material should be wasted, where
rowed ; what material should be carried forward, what backw
The study of the mass diagram has shown that the arrangem
adopted is the most economical.

The exact stations of the points A, B, C, D, etc., can be de
mined accurately from the cross-section notes and the volu
of earthwork already computed, if this should seem desirabl


MASS DIAGRAM
0
10
20
30
40
50
60
70
80
A
B
C
D
E
F
G
H
J
K
L
M
N
O
P
R
S
PROFILE
Waste
Borrow
Borrow
Waste
Borrow
Waste unless Profile is continued



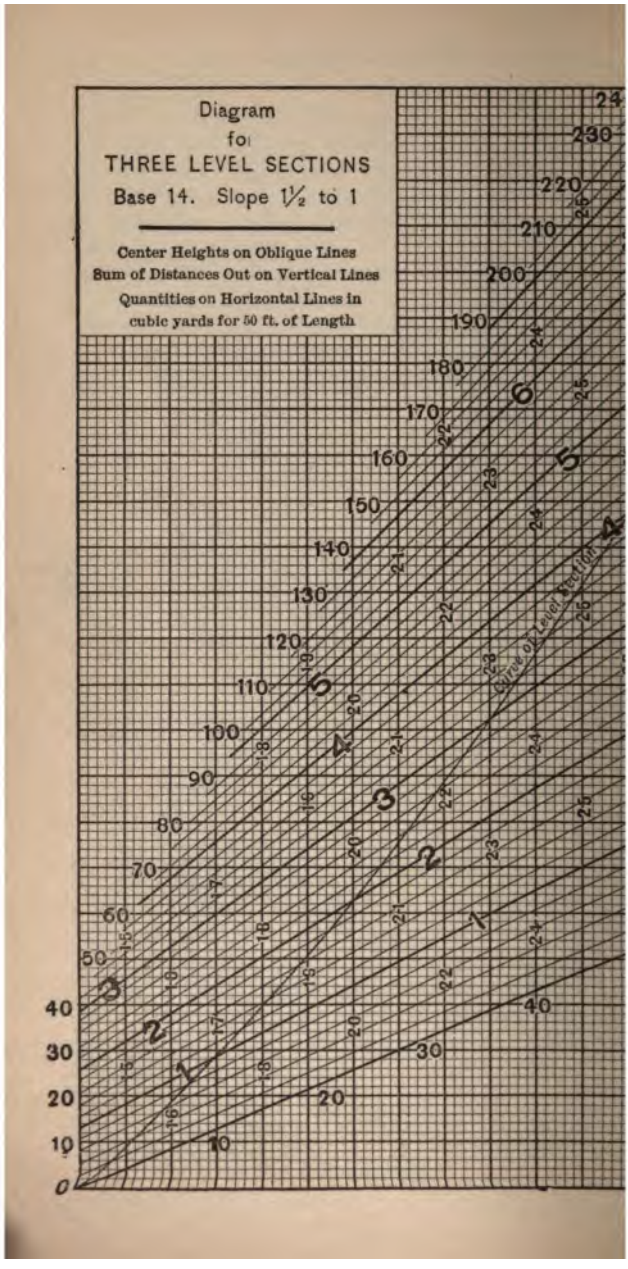
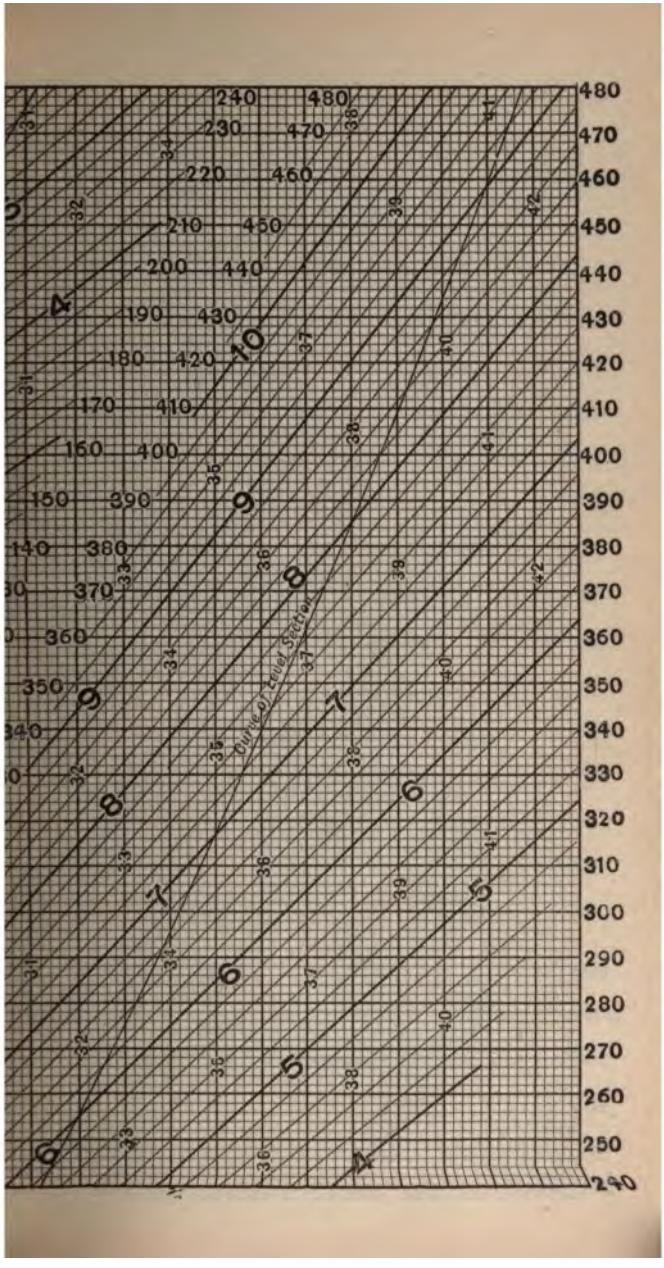
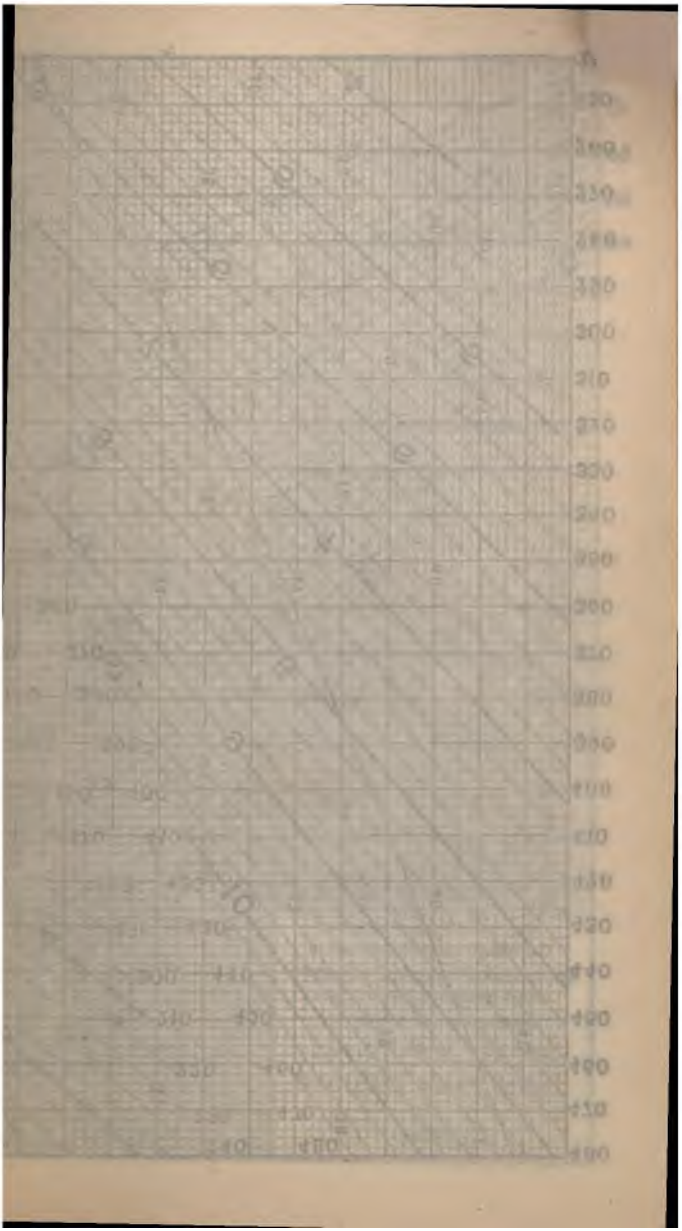
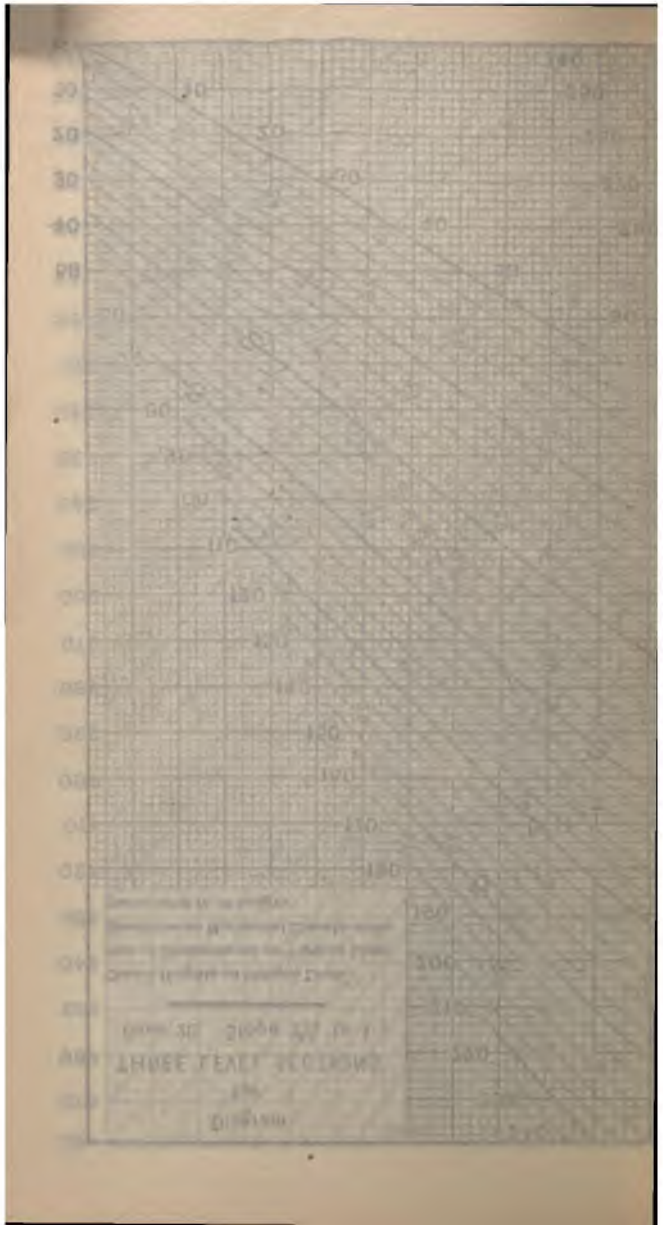


Diagram
for
THREE LEVEL SECTIONS
Base 14. Slope 1½ to 1
Center Heights on Oblique Lines
Sum of Distances Out on Vertical Lines
Quantities on Horizontal Lines in
cubic yards for 50 ft. of Length
Center of Level Section
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240


Burned Fuel Section





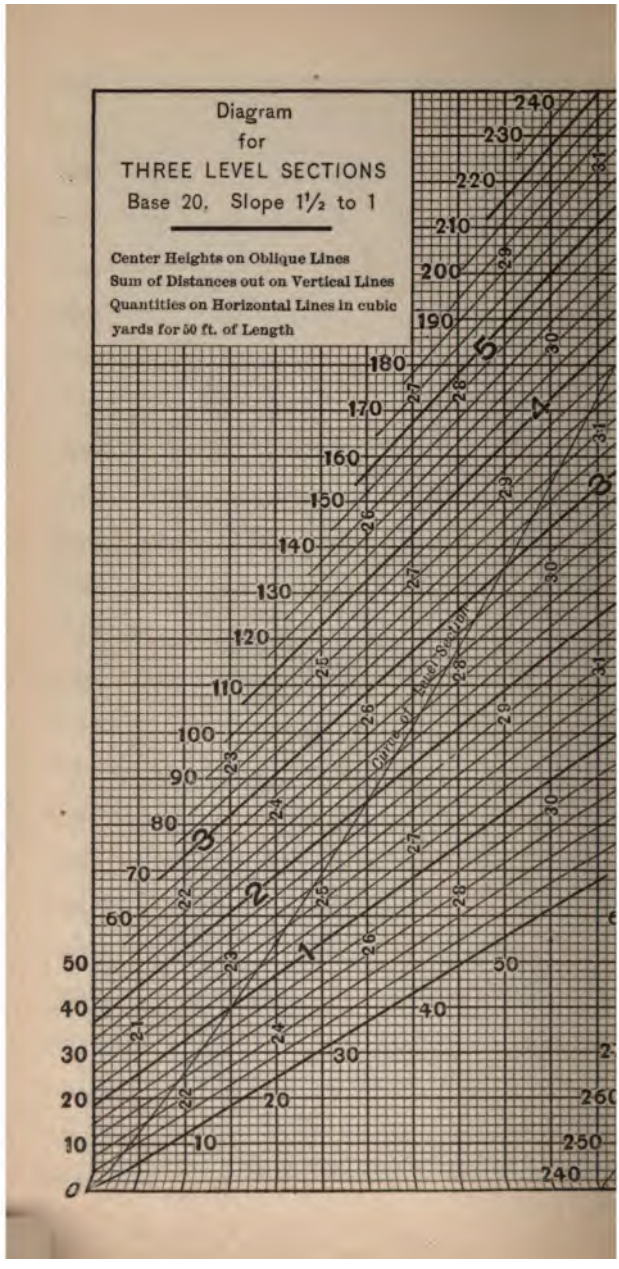
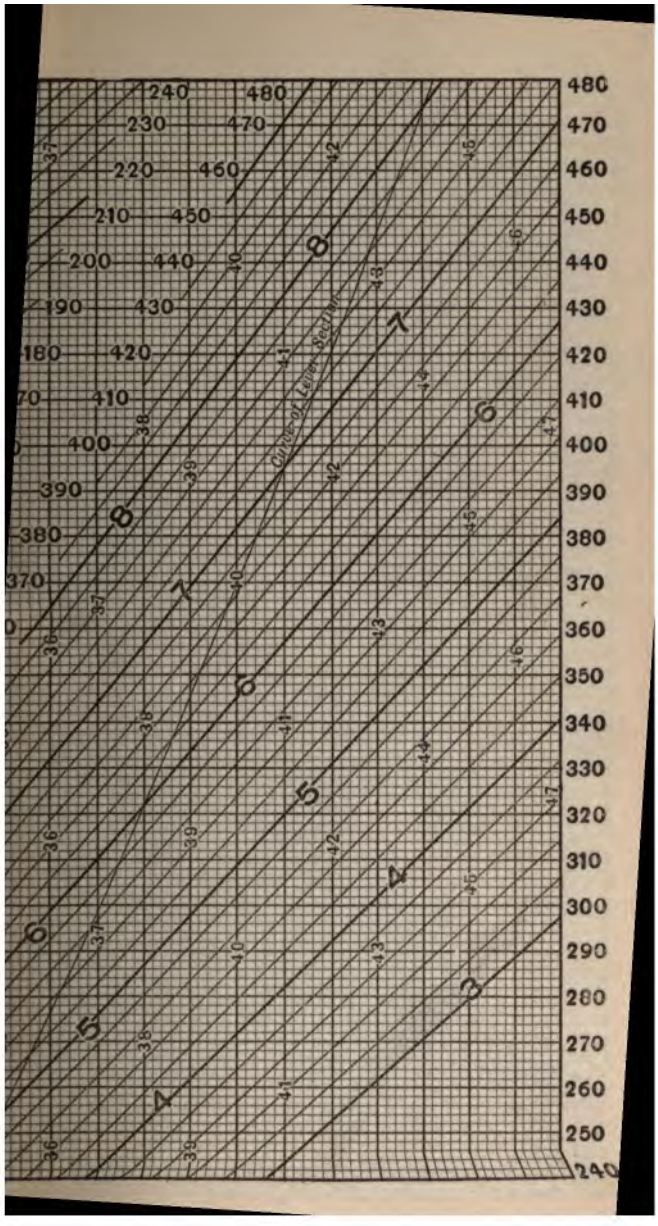
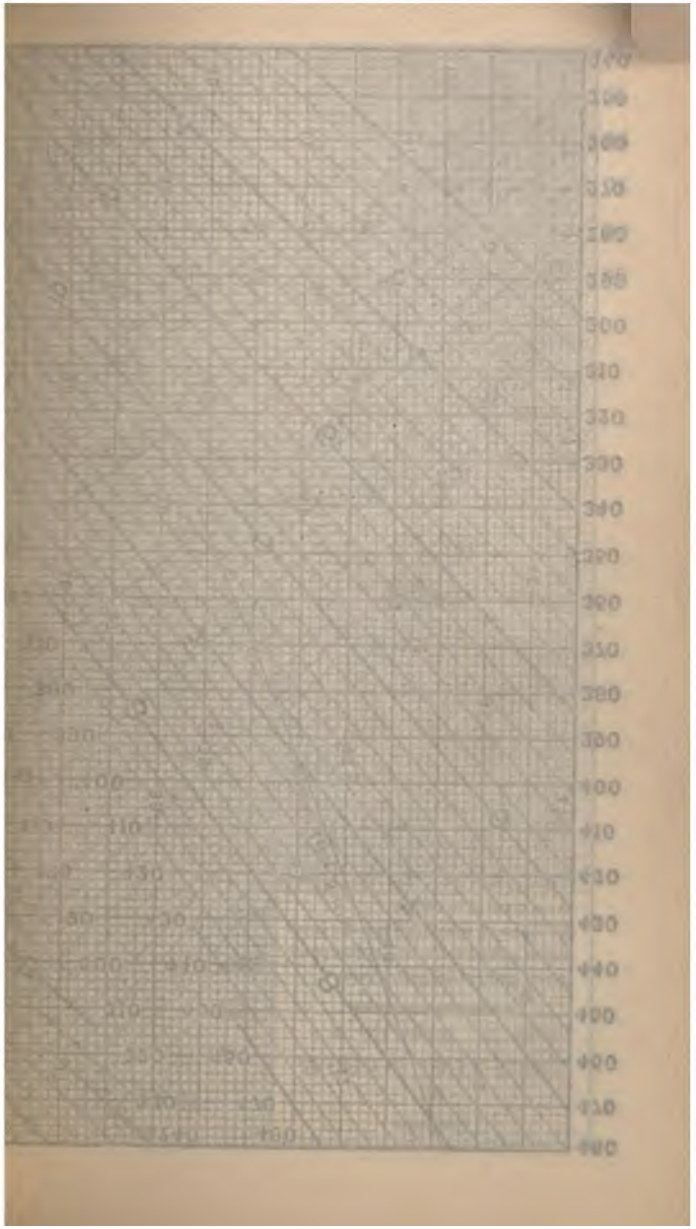
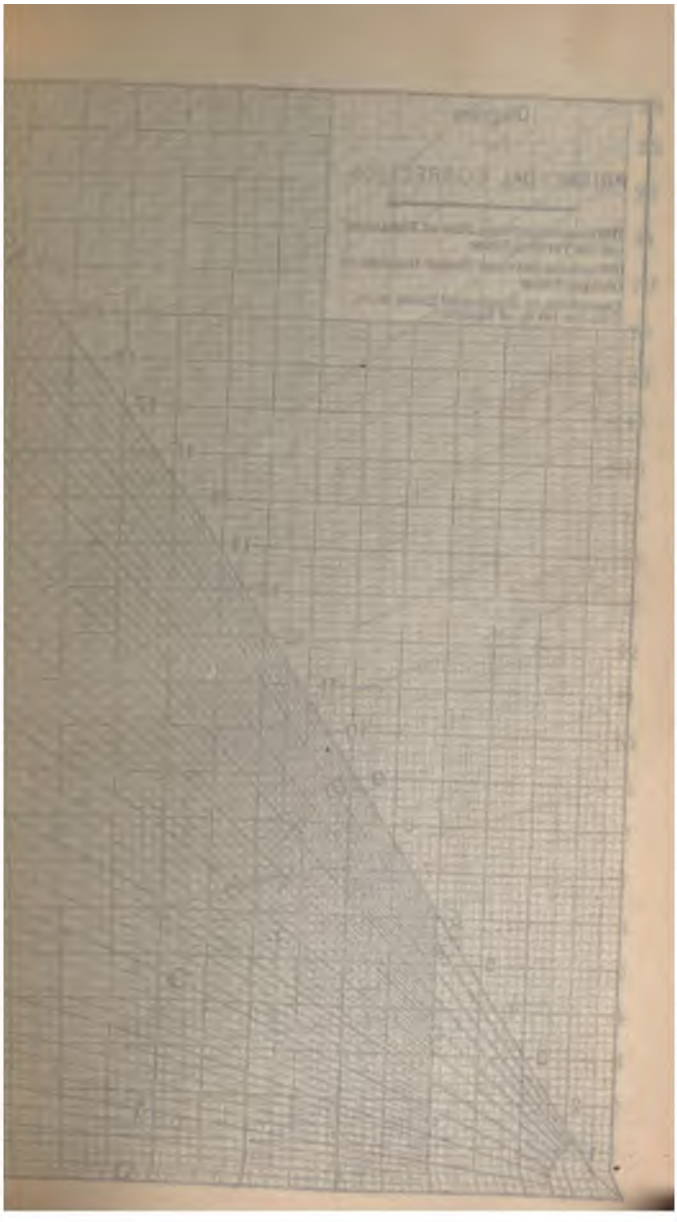


Diagram
for
THREE LEVEL SECTIONS
Base 20. Slope 1½ to 1
Center Heights on Oblique Lines
Sum of Distances out on Vertical Lines
Quantities on Horizontal Lines in cubic yards for 50 ft. of Length
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
5
4
3
2
1
50
40
30
20
10
250
240


240
230
220
210
200
190
180
70
480
470
460
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
Outline of Lower Section
8
7
6
5
4
3





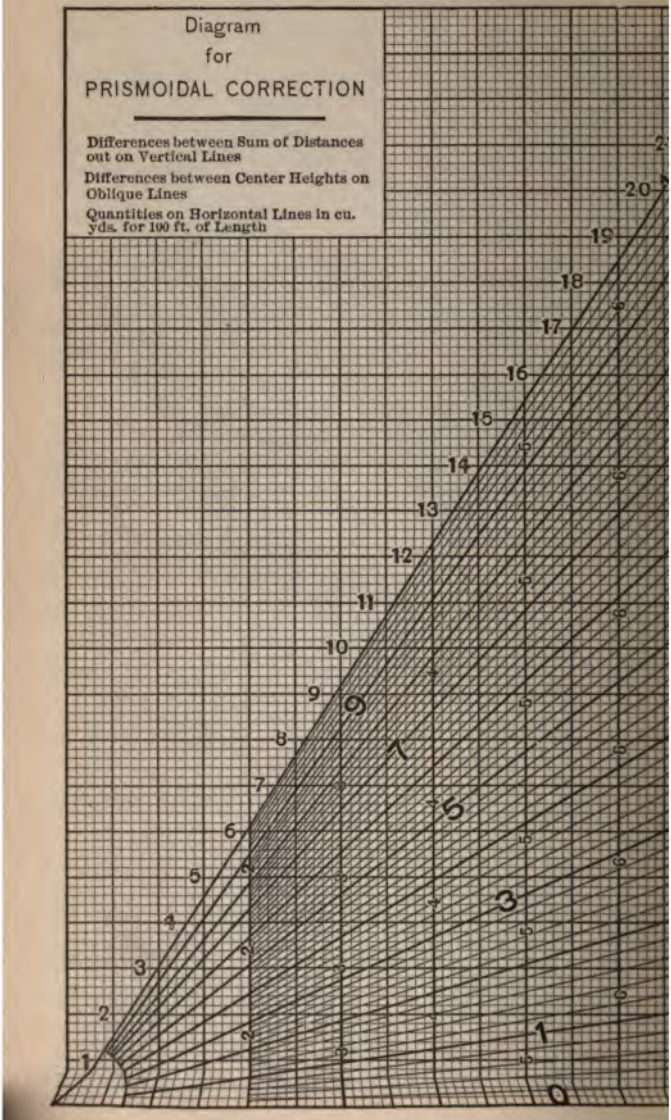
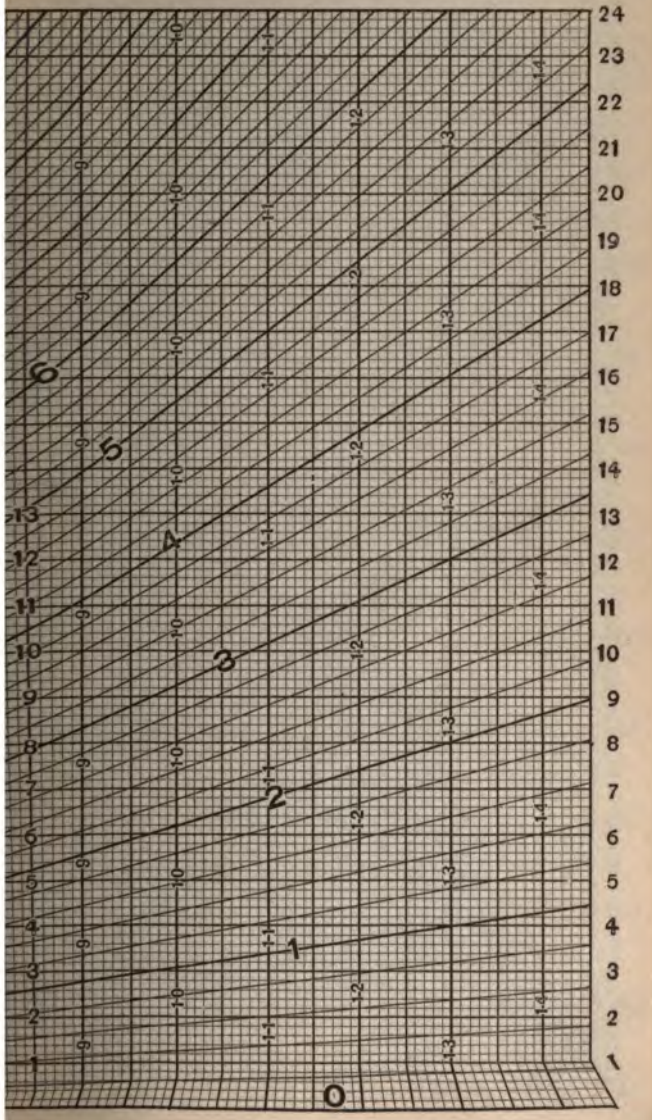
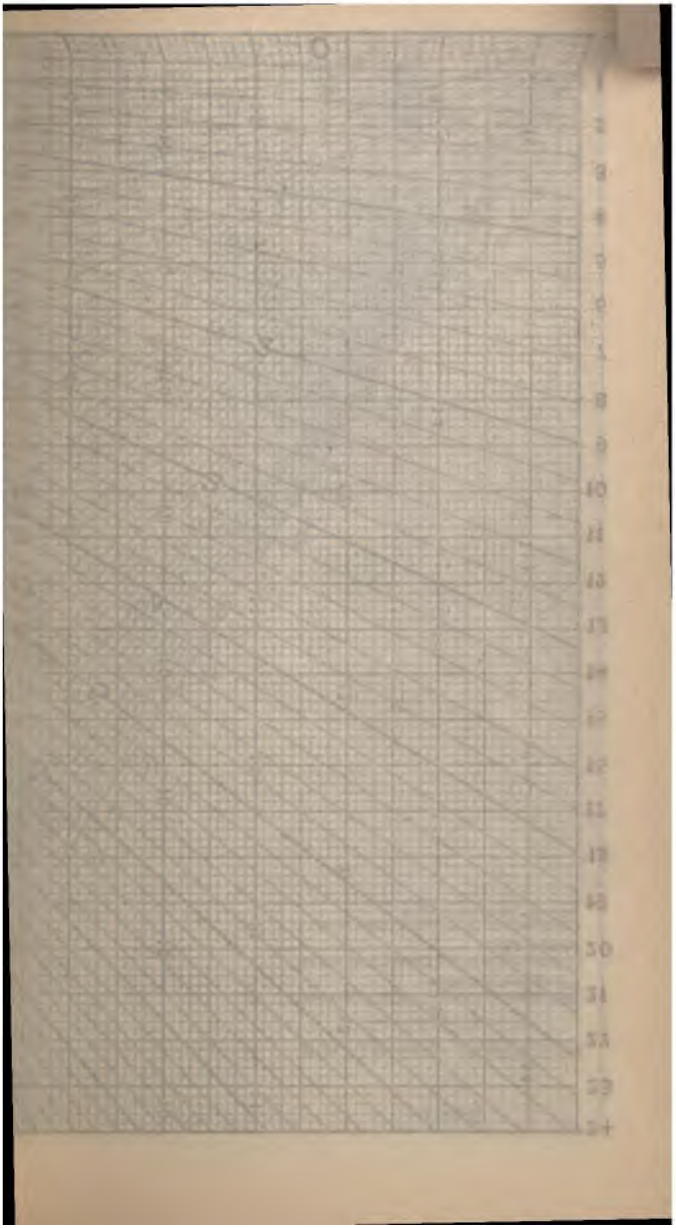
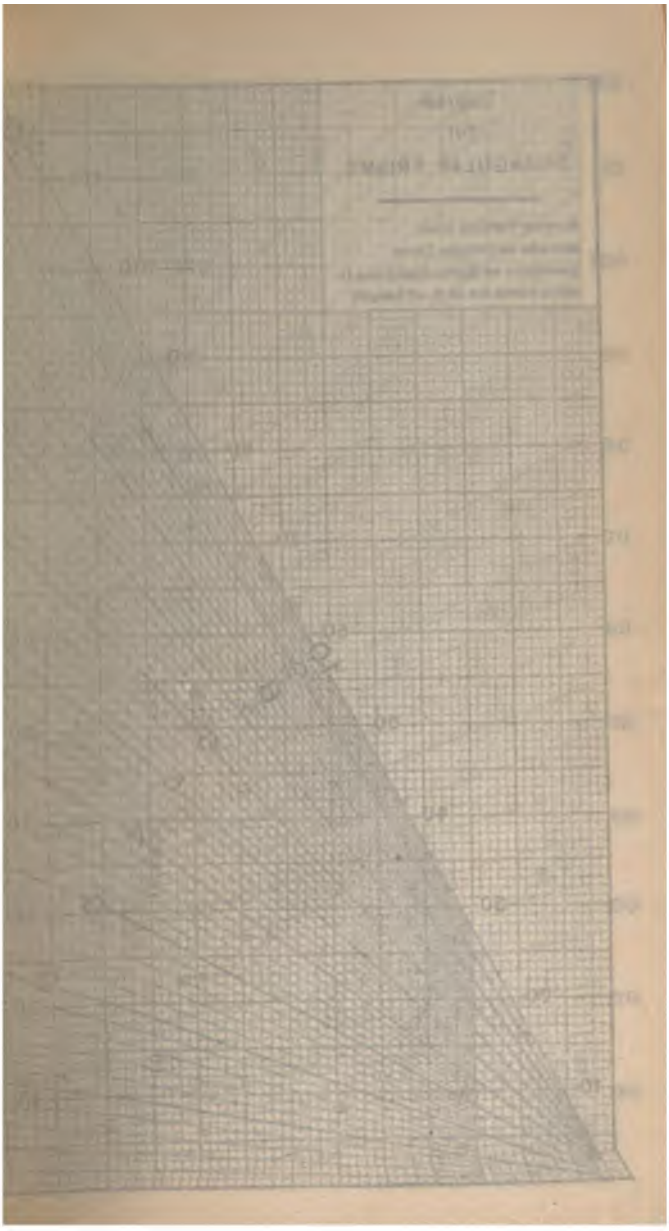


Diagram
for
PRISMOIDAL CORRECTION
Differences between Sum of Distances out on Vertical Lines
Differences between Center Heights on Oblique Lines
Quantities on Horizontal Lines in cu. yds. for 100 ft. of Length
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
0
1
3
5
7
9


24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
6
5
4
3
2
1
-13
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
-0
-1
-2
-3
-4





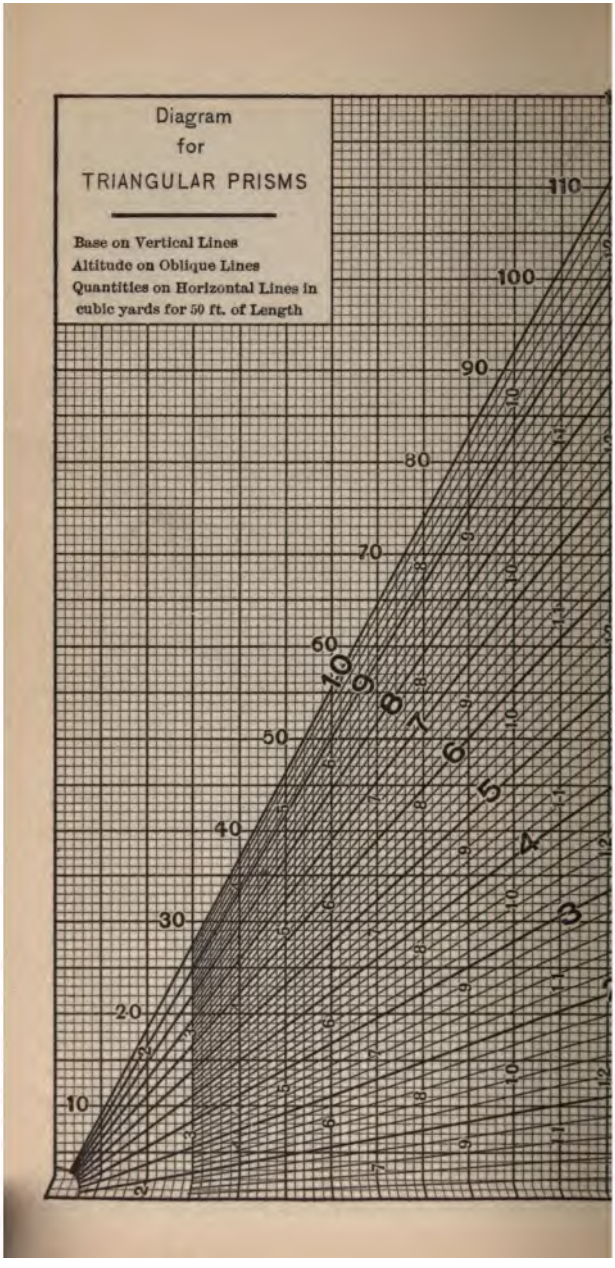
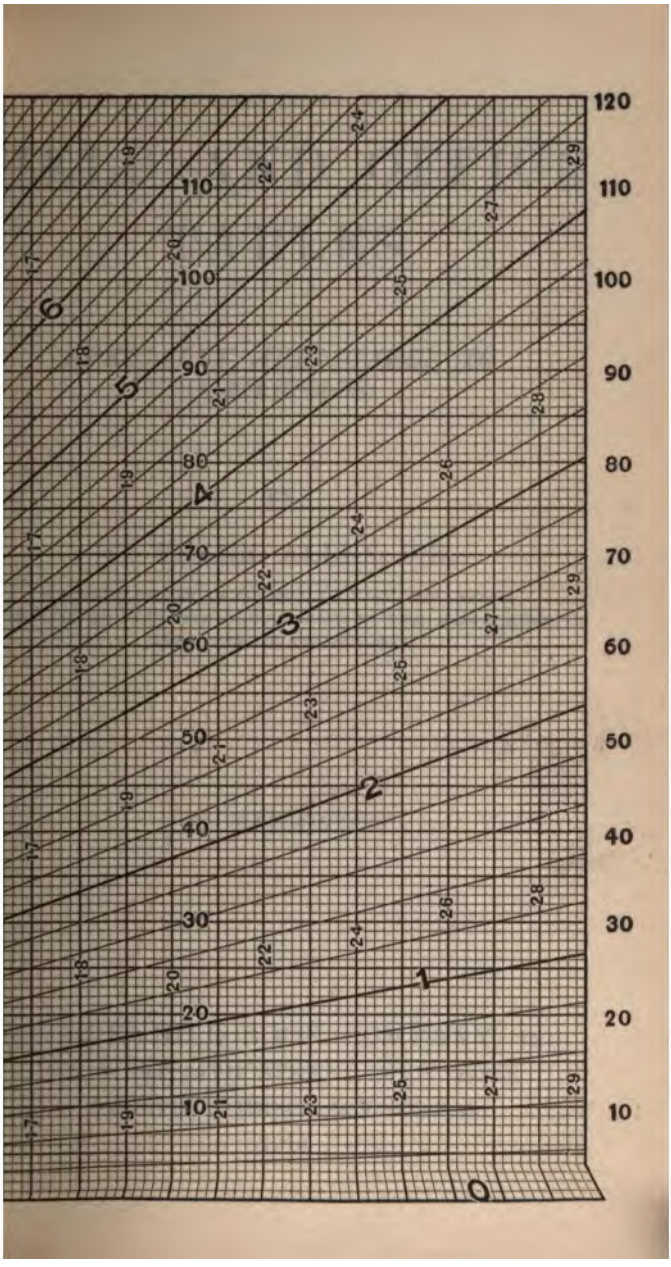


Diagram
for
TRIANGULAR PRISMS
Base on Vertical Lines
Altitude on Oblique Lines
Quantities on Horizontal Lines in
cubic yards for 50 ft. of Length
110
100
90
80
70
60
50
40
30
20
10


120
110
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6

FIELD AND OFFICE TABLES

SPECIALLY APPLICABLE TO RAILROADS

BY

C. FRANK ALLEN, S.B.

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
PROFESSOR OF RAILROAD ENGINEERING IN THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

REVISED EDITION

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PREFACE

It is hoped that these tables will be found more complete and perfect than those which have preceded. Among them are convenient tables for easement curves and for earthwork computation, several of which are altogether new. These include the "Cubic Spiral" easement curve, which is very simple, being arranged for a uniform chord length of 30 feet, and giving all deflection angles for a large variety of spirals; also the "Offsets from Tangent for a 10° Curve" and "Angles Proportionate to Squares of Distances," both of which are specially applicable to easement curves, but should be found useful for other purposes. The two latter allow the rapid and simple working of spirals of any length or for any set-off from the tangent.

The tables for Earthwork Computation should meet with favor. Those for regular three-level sections and for prismoidal correction are based upon tables used for computing the earthwork on many hundred miles on a prominent western railroad, and that for triangular prisms is similar in principle to that for prismoidal correction.

Other tables seldom found in books suitable for field use are "Acres for Strip 100 Feet Wide," "Metric Curves," "Velocity Heights," and "Mean Refractions in Declination," while the "Stadia Reduction Tables" are more complete than those common in field tables.

The table for "Tangent Distances for a 1° Curve" gives values for every minute up to 96° and the table of "Corrections" is full enough to render interpolation unnecessary. This will allow greater speed and the saving of much time for an entire field party.

There are many points of arrangement and typography which are intended to facilitate work or render errors less probable. Great care has been taken both in computing and proof-reading to secure absence from error. The plate-proof has been twice read under the author's direction, and other tests applied which have required the use (in adding) of every figure in the tables. The opportunity for comparison with other published tables and the running down of discrepancies has given opportunity for a high degree of accuracy, and these tables are believed to be superior in this respect.

The "*Barometric Heights*" are Professor Airy's and the "*Stadia Reductions*" are Winslow's from the "Reports of the Pennsylvania *Geological Survey*." The "Logarithms" and "Sines, *Cosines, Tangents* and Cotangents," both natural and logarithmic,

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Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.
0° 0′	∞	∞	1° 0′	5729.65	3.758128	2° 0′	2864.93	3.457115
1	343774.68	5.536274	1	5635.72	.750950	1	2841.26	.453511
2	171887.34	.235244	2	5544.83	.743888	2	2817.97	.449937
3	114591.56	.059153	3	5456.82	.736939	3	2795.06	.446392
4	85943.67	4.934214	4	5371.56	.730100	4	2772.53	.442876
5	68754.94	4.837304	5	5288.92	3.723367	5	2750.35	3.439388
6	57295.79	.758123	6	5208.79	.716737	6	2728.52	.435928
7	49110.68	.691176	7	5131.05	.710206	7	2707.04	.432495
8	42971.84	.633184	8	5055.59	.703772	8	2685.89	.429089
9	38197.20	.582031	9	4982.33	.697432	9	2665.08	.425710
10	34377.48	4.536274	10	4911.15	3.691183	10	2644.58	3.422356
11	31252.26	.494881	11	4841.98	.685023	11	2624.39	.419029
12	28647.90	.457093	12	4774.74	.678949	12	2604.51	.415727
13	26444.22	.422331	13	4709.33	.672959	13	2584.93	.412449
14	24555.35	.390146	14	4645.69	.667051	14	2565.65	.409197
15	22918.33	4.360183	15	4583.75	3.661221	15	2546.64	3.405968
16	21485.94	.332154	16	4523.44	.655469	16	2527.92	.402763
17	20222.06	.305825	17	4464.70	.649792	17	2509.47	.399582
18	19098.61	.281002	18	4407.46	.644189	18	2491.29	.396424
19	18093.43	.257521	19	4351.67	.638656	19	2473.37	.393289
20	17188.76	4.235244	20	4297.28	3.633194	20	2455.70	3.390176
21	16370.25	.214055	21	4244.23	.627799	21	2438.29	.387085
22	15626.15	.193852	22	4192.47	.622470	22	2421.12	.384016
23	14946.75	.174547	23	4141.96	.617206	23	2404.19	.380969
24	14323.97	.156064	24	4092.66	.612005	24	2387.50	.377943
25	13751.02	4.138335	25	4044.51	3.606866	25	2371.04	3.374938
26	13222.13	.121302	26	3997.48	.601787	26	2354.80	.371954
27	12732.43	.104911	27	3951.54	.596766	27	2338.78	.368990
28	12277.70	.089117	28	3906.64	.591803	28	2322.98	.366046
29	11854.33	.073877	29	3862.74	.586896	29	2307.39	.363122
30	11459.19	4.059154	30	3819.83	3.582044	30	2292.01	3.360217
31	11089.54	.044914	31	3777.85	.577245	31	2276.84	.357332
32	10743.00	.031125	32	3736.79	.572499	32	2261.86	.354466
33	10417.45	.017762	33	3696.61	.567804	33	2247.08	.351618
34	10111.06	.004797	34	3657.29	.563160	34	2232.49	.348789
35	9822.18	3.992208	35	3618.80	3.558564	35	2218.09	3.345979
36	9549.34	.979973	36	3581.10	.554017	36	2203.87	.343187
37	9291.25	.968074	37	3544.19	.549517	37	2189.84	.340412
38	9046.75	.956492	38	3508.02	.545063	38	2175.98	.337655
39	8814.78	.945212	39	3472.59	.540654	39	2162.30	.334915
40	8594.42	3.934216	40	3437.87	3.536289	40	2148.79	3.332193
41	8384.80	.923493	41	3403.83	.531968	41	2135.44	.329488
42	8185.16	.913027	42	3370.46	.527690	42	2122.26	.326799
43	7994.81	.902808	43	3337.74	.523453	43	2109.24	.324127
44	7813.11	.892824	44	3305.65	.519257	44	2096.39	.321471
45	7639.49	3.883064	45	3274.17	3.515101	45	2083.68	3.318832
46	7473.42	.873519	46	3243.29	.510985	46	2071.13	.316208
47	7314.41	.864179	47	3212.98	.506908	47	2058.73	.313600
48	7162.03	.855036	48	3183.23	.502868	48	2046.48	.311008
49	7015.87	.846081	49	3154.03	.498866	49	2034.37	.308431
50	6875.55	3.837308	50	3125.36	3.494900	50	2022.41	3.305869
51	6740.74	.828708	51	3097.20	.490970	51	2010.59	.303323
52	6611.12	.820275	52	3069.55	.487075	52	1998.90	.300791
53	6486.38	.812002	53	3042.39	.483215	53	1987.35	.298274
54	6366.26	.803885	54	3015.71	.479389	54	1975.93	.295771
55	6250.51	3.795916	55	2989.48	3.475596	55	1964.64	3.293283
56	6138.90	.788091	56	2963.72	.471836	56	1953.48	.290809
57	6031.20	.780404	57	2938.39	.468109	57	1942.44	.288349
58	5927.22	.772851	58	2913.49	.464413	58	1931.53	.285902
59	5826.76	.765427	59	2889.01	.460749	59	1920.75	.283470
60	5729.65	3.758128	60	2864.93	3.457115	60	1910.08	3.281051

Deg D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.
9° 0′	637.27	2.804327	11° 0′	521.67	2.717397	13° 0′	441.68
2	634.93	.802724	2	520.10	.716087	2	440.56
4	632.60	.801128	4	518.54	.714781	4	439.44
6	630.29	.799538	6	516.99	.713479	6	438.33
8	627.99	.797953	8	515.44	.712181	8	437.22
10	625.71	2.796374	10	513.91	2.710887	10	436.12
12	623.45	.794801	12	512.38	.709596	12	435.02
14	621.20	.793234	14	510.87	.708310	14	433.93
16	618.97	.791673	16	509.36	.707027	16	432.84
18	616.76	.790117	18	507.86	.705748	18	431.76
20	614.56	2.788566	20	506.38	2.704473	20	430.69
22	612.38	.787021	22	504.90	.703202	22	429.62
24	610.21	.785482	24	503.42	.701934	24	428.56
26	608.06	.783948	26	501.96	.700671	26	427.50
28	605.93	.782420	28	500.51	.699410	28	426.44
30	603.80	2.780897	30	499.06	2.698154	30	425.40
32	601.70	.779379	32	497.62	.696901	32	424.35
34	599.61	.777867	34	496.19	.695652	34	423.32
36	597.53	.776360	36	494.77	.694407	36	422.28
38	595.47	.774858	38	493.36	.693165	38	421.26
40	593.42	2.773361	40	491.96	2.691926	40	420.23
42	591.38	.771870	42	490.56	.690692	42	419.22
44	589.36	.770383	44	489.17	.689460	44	418.20
46	587.36	.768902	46	487.79	.688233	46	417.19
48	585.36	.767426	48	486.42	.687008	48	416.19
50	583.38	2.765955	50	485.05	2.685788	50	415.19
52	581.42	.764489	52	483.69	.684570	52	414.20
54	579.46	.763028	54	482.34	.683357	54	413.21
56	577.53	.761572	56	481.00	.682146	56	412.23
58	575.60	.760120	58	479.67	.680939	58	411.25
10° 0′	573.69	2.758674	12° 0′	478.34	2.679735	14° 0′	410.28
2	571.78	.757232	2	477.02	.678535	2	409.31
4	569.90	.755796	4	475.71	.677338	4	408.34
6	568.02	.754364	6	474.40	.676145	6	407.38
8	566.16	.752937	8	473.10	.674954	8	406.42
10	564.31	2.751514	10	471.81	2.673767	10	405.47
12	562.47	.750096	12	470.53	.672584	12	404.53
14	560.64	.748683	14	469.25	.671403	14	403.58
16	558.82	.747274	16	467.98	.670226	16	402.65
18	557.02	.745870	18	466.72	.669052	18	401.71
20	555.23	2.744471	20	465.46	2.667881	20	400.78
22	553.45	.743076	22	464.21	.666713	22	399.86
24	551.68	.741686	24	462.96	.665549	24	398.94
26	549.92	.740300	26	461.73	.664388	26	398.02
28	548.17	.738918	28	460.50	.663229	28	397.11
30	546.44	2.737541	30	459.28	2.662074	30	396.20
32	544.71	.736169	32	458.06	.660922	32	395.30
34	543.00	.734800	34	456.85	.659773	34	394.40
36	541.30	.733436	36	455.65	.658628	36	393.50
38	539.61	.732077	38	454.45	.657485	38	392.61
40	537.92	2.730721	40	453.26	2.656345	40	391.72
42	536.25	.729370	42	452.07	.655208	42	390.84
44	534.59	.728023	44	450.89	.654075	44	389.96
46	532.94	.726681	46	449.72	.652944	46	389.08
48	531.30	.725342	48	448.56	.651816	48	388.21
50	529.67	2.724008	50	447.40	2.650691	50	387.34
52	528.05	.722677	52	446.24	.649570	52	386.48
54	526.44	.721351	54	445.09	.648451	54	385.62
56	524.84	.720029	56	443.95	.647335	56	384.77
58	523.25	.718711	58	442.81	.646221	58	383.91
60	521.67	2.717397	60	441.68	2.645111	60	383.06

Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.
15° 0′	383.06	2.583272	20° 0′	287.94	2.459300	30° 0′	193.19	2.285974
5	380.96	580880	10	285.58	455733	10	192.14	283623
10	378.88	578501	20	283.27	452195	20	191.11	281286
15	376.82	576135	30	280.99	448688	30	190.09	278963
20	374.79	573783	40	278.75	445209	40	189.08	276652
25	372.77	571443	50	276.54	441759	50	188.09	274355
30	370.78	2.569116	21° 0′	274.37	2.438337	31° 0′	187.10	2.272071
35	368.81	566802	10	272.23	434943	10	186.12	269800
40	366.86	564500	20	270.13	431575	20	185.16	267541
45	364.93	562210	30	268.06	428235	30	184.20	265295
50	363.02	559933	40	266.02	424921	40	183.26	263062
55	361.13	557668	50	264.02	421633	50	182.32	260841
16° 0′	359.26	2.555415	22° 0′	262.04	2.418371	32° 0′	181.40	2.258632
5	357.42	553173	10	260.10	415134	10	180.48	256435
10	355.59	550944	20	258.18	411922	20	179.58	254250
15	353.77	548726	30	256.29	408734	30	178.68	252077
20	351.98	546519	40	254.43	405571	40	177.79	249916
25	350.21	544324	50	252.60	402431	50	176.92	247766
30	348.45	2.542140	23° 0′	250.79	2.399315	33° 0′	176.05	2.245628
35	346.71	539968	10	249.01	396222	10	175.19	243501
40	344.99	537806	20	247.26	393151	20	174.34	241386
45	343.29	535655	30	245.53	390103	30	173.49	239282
50	341.60	533516	40	243.82	387077	40	172.66	237188
55	339.93	531386	50	242.14	384073	50	171.83	235106
17° 0′	338.27	2.529268	24° 0	240.49	2.381091	34° 0′	171.02	2.233035
5	336.64	527160	10	238.85	378130	10	170.21	230974
10	335.01	525062	20	237.24	375190	20	169.40	228924
15	333.41	522975	30	235.65	372270	30	168.61	226884
20	331.82	520898	40	234.08	369371	40	167.82	224855
25	330.24	518831	50	232.54	366492	50	167.05	222837
30	328.68	2.516774	25° 0′	231.01	2.363633	35° 0′	166.28	2.220828
35	327.13	514727	10	229.51	360794	10	165.51	218830
40	325.60	512690	20	228.02	357974	20	164.76	216842
45	324.09	510662	30	226.55	355173	30	164.01	214863
50	322.59	508645	40	225.11	352391	40	163.27	212895
55	321.10	506636	50	223.68	349627	50	162.53	210937
18° 0′	319.62	2.504638	26° 0′	222.27	2.346882	36° 0′	161.80	2.208988
5	318.16	502648	10	220.88	344155	10	161.08	207048
10	316.71	500668	20	219.51	341446	20	160.37	205119
15	315.28	498697	30	218.15	338755	30	159.66	203198
20	313.86	496736	40	216.81	336081	40	158.96	201288
25	312.45	494783	50	215.49	333424	50	158.27	199386
30	311.06	2.492839	27° 0′	214.18	2.330785	37° 0′	157.58	2.197494
35	309.67	490904	10	212.89	328162	10	156.90	195610
40	308.30	488978	20	211.62	325556	20	156.22	193736
45	306.95	487061	30	210.36	322967	30	155.55	191871
50	305.60	485152	40	209.12	320393	40	154.89	190014
55	304.27	483252	50	207.89	317836	50	154.23	188167
19° 0′	302.94	2.481361	28° 0′	206.68	2.315295	38° 0′	153.58	2.186328
5	301.63	479478	10	205.48	312769	10	152.93	184498
10	300.33	477603	20	204.30	310259	20	152.29	182676
15	299.04	475736	30	203.13	307764	30	151.66	180863
20	297.77	473878	40	201.97	305285	40	151.03	179059
25	296.50	472028	50	200.83	302820	50	150.41	177263
30	295 25	2.470186	29° 0′	199.70	2.300370	39° 0′	149.79	2.175475
35	294.00	468352	10	198.58	297935	10	149.17	173695
40	292.77	466526	20	197.48	295515	20	148.57	171924
45	291.55	464708	30	196.38	293108	30	147.97	170160
50	290.33	462897	40	195.31	290716	40	147.37	168405
55	289.13	461095	50	194.24	288338	50	146.78	166658
60	287.94	2.459300	60	193.19	2.285974	60	146.19	2.164918

Deg D.	Radius R.	Log. R.	Deg. D.	Radius R.	Log. R.	Deg. D.	Radius R.
9° 0′	637.27	2.804327	11° 0′	521.67	2.717397	13° 0′	441.68
2	634.93	.802724	2	520.10	.716087	2	440.56
4	632.60	.801128	4	518.54	.714781	4	439.44
6	630.29	.799538	6	516.99	.713479	6	438.33
8	627.99	.797953	8	515.44	.712181	8	437.22
10	625.71	2.796374	10	513.91	2.710887	10	436.12
12	623.45	.794801	12	512.38	.709596	12	435.02
14	621.20	.793234	14	510.87	.708310	14	433.93
16	618.97	.791673	16	509.36	.707027	16	432.84
18	616.76	.790117	18	507.86	.705748	18	431.76
20	614.56	2.788566	20	506.38	2.704473	20	430.69
22	612.38	.787021	22	504.90	.703202	22	429.62
24	610.21	.785482	24	503.42	.701934	24	428.56
26	608.06	.783948	26	501.96	.700671	26	427.50
28	605.93	.782420	28	500.51	.699410	28	426.44
30	603.80	2.780897	30	499.06	2.698154	30	425.40
32	601.70	.779379	32	497.62	.696901	32	424.35
34	599.61	.777867	34	496.19	.695652	34	423.32
36	597.53	.776360	36	494.77	.694407	36	422.28
38	595.47	.774858	38	493.36	.693165	38	421.26
40	593.42	2.773361	40	491.96	2.691926	40	420.23
42	591.38	.771870	42	490.56	.690692	42	419.22
44	589.36	.770383	44	489.17	.689460	44	418.20
46	587.36	.768902	46	487.79	.688233	46	417.19
48	585.36	.767426	48	486.42	.687008	48	416.19
50	583.38	2.765955	50	485.05	2.685788	50	415.19
52	581.42	.764489	52	483.69	.684570	52	414.20
54	579.46	.763028	54	482.34	.683357	54	413.21
56	577.53	.761572	56	481.00	.682146	56	412.23
58	575.60	.760120	58	479.67	.680939	58	411.25
10° 0′	573.69	2.758674	12° 0′	478.34	2.679735	14° 0′	410.28
2	571.78	.757232	2	477.02	.678535	2	409.31
4	569.90	.755796	4	475.71	.677338	4	408.34
6	568.02	.754364	6	474.40	.676145	6	407.38
8	566.16	.752937	8	473.10	.674954	8	406.42
10	564.31	2.751514	10	471.81	2.673767	10	405.47
12	562.47	.750096	12	470.53	.672584	12	404.53
14	560.64	.748683	14	469.25	.671403	14	403.58
16	558.82	.747274	16	467.98	.670226	16	402.65
18	557.02	.745870	18	466.72	.669052	18	401.71
20	555.23	2.744471	20	465.46	2.667881	20	400.78
22	553.45	.743076	22	464.21	.666713	22	399.86
24	551.68	.741686	24	462.96	.665549	24	398.94
26	549.92	.740300	26	461.73	.664388	26	398.02
28	548.17	.738918	28	460.50	.663229	28	397.11
30	546.44	2.737541	30	459.28	2.662074	30	396.20
32	544.71	.736169	32	458.06	.660922	32	395.30
34	543.00	.734800	34	456.85	.659773	34	394.40
36	541.30	.733436	36	455.65	.658628	36	393.50
38	539.61	.732077	38	454.45	.657485	38	392.61
40	537.92	2.730721	40	453.26	2.656345	40	391.72
42	536.25	.729370	42	452.07	.655208	42	390.84
44	534.59	.728023	44	450.89	.654075	44	389.96
46	532.94	.726681	46	449.72	.652944	46	389.08
48	531.30	.725342	48	448.56	.651816	48	388.21
50	529.67	2.724008	50	447.40	2.650691	50	387.34
52	528.05	.722677	52	446.24	.649570	52	386.48
54	526.44	.721351	54	445.09	.648451	54	385.62
56	524.84	.720029	56	443.95	.647335	56	384.7
58	523.25	.718711	58	442.81	.646221	58	383.
60	521.67	2.717397	60	441.68	2.645111	60	382.

TABLE II.—TANGENT OFFSETS AND MIDDLE ORDINATES.

Deg.	Tang. Offs.	Mid. Ord.	Deg.	Tang. Offs.	Mid. Ord.	Deg.	Tang. Offs.	Mid. Ord.
6° 0′	5.234	1.309	16° 0′	13.917	3.496	26° 0′	22.495	5.697
10	.379	.346	10	14.061	.533	10	.637	.734
20	.524	.382	20	.205	.569	20	.778	.770
30	.669	.418	30	.349	.606	30	.920	.807
40	.814	.455	40	.493	.643	40	23.062	.844
50	.960	.491	50	.637	.679	50	.203	.881
7° 0′	6.105	1.528	17° 0′	14.781	3.716	27° 0′	23.345	5.918
10	.250	.564	10	.925	.752	10	.486	.955
20	.395	.600	20	15.069	.789	20	.627	.992
30	.540	.637	30	.212	.825	30	.769	6.029
40	.685	.673	40	.356	.862	40	.910	.065
50	.831	.710	50	.500	.899	50	24.051	.102
8° 0′	6.976	1.746	18° 0′	15.643	3.935	28° 0′	24.192	6.139
10	7.121	.782	10	.787	.972	10	.333	.176
20	.266	.819	20	.931	4.008	20	.474	.213
30	.411	.855	30	16.074	.045	30	.615	.250
40	.556	.892	40	.218	.081	40	.756	.287
50	.701	.928	50	.361	.118	50	.897	.324
9° 0′	7.846	1.965	19° 0′	16.505	4.155	29° 0′	25.038	6.361
10	.991	2.001	10	.648	.191	10	.179	.398
20	8.136	.037	20	.792	.228	20	.320	.435
30	.281	.074	30	.935	.265	30	.460	.472
40	.426	.110	40	17.078	.301	40	.601	.509
50	.571	.147	50	.222	.338	50	.741	.546
10° 0′	8.716	2.183	20° 0′	17.365	4.374	30° 0′	25.882	6.583
10	.860	.219	10	.508	.411	10	26.022	.620
20	9.005	.256	20	.651	.448	20	.163	.657
30	.150	.292	30	.794	.484	30	.303	.694
40	.295	.329	40	.937	.521	40	.443	.731
50	.440	.365	50	18.081	.558	50	.584	.768
11° 0′	9.585	2.402	21° 0′	18.224	4.594	31° 0′	26.724	6.805
10	.729	.438	10	.367	.631	20	27.004	.879
20	.874	.475	20	.509	.668	40	.284	.953
30	10.019	.511	30	.652	.704	32° 0′	.564	7.027
40	.164	.547	40	.795	.741	20	.843	.101
50	.308	.584	50	.938	.778	40	28.123	.175
12° 0′	10.453	2.620	22° 0′	19.081	4.814	33° 0′	28.402	7.250
10	.597	.657	10	.224	.851	20	.680	.324
20	.742	.693	20	.366	.888	40	.959	.398
30	.887	.730	30	.509	.925	34° 0′	29.237	.473
40	11.031	.766	40	.652	.961	20	.515	.547
50	.176	.803	50	.794	.998	40	.793	.621
13° 0′	11.320	2.839	23° 0′	19.937	5.035	35° 0′	30.071	7.696
10	.465	.876	10	20.079	.071	20	.348	.770
20	.609	.912	20	.222	.108	40	.625	.845
30	.754	.949	30	.364	.145	36° 0′	.902	.919
40	.898	.985	40	.507	.182	20	31.178	.994
50	12.043	3.022	50	.649	.218	40	.454	8.068
14° 0′	12.187	3.058	24° 0′	20.791	5.255	37° 0′	31.730	8.143
10	.331	.095	10	.933	.292	20	32.006	.218
20	.476	.131	20	21.076	.329	40	.282	.292
30	.620	.168	30	.218	.366	38° 0′	.557	.367
40	.764	.204	40	.360	.402	20	.832	.442
50	.908	.241	50	.502	.439	40	33.106	.517
15° 0′	13.053	3.277	25° 0′	1.644	5.476	39° 0′	33.381	8.592
10	.197	.314	10	.786	.513	20	.655	.667
20	.341	.350	20	.928	.549	40	.929	.741
30	.485	.387	30	22.070	.586	40° 0′	34.202	.816
40	.629	.423	40	.212	.623	20	.475	.891
50	.773	.460	50	.353	.660	40	.748	.966
60	13.917	3.496	60	22.495	5.697	41° 0′	35.021	9.041

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE.

M.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°
0	0.0	50.0	100.0	150.0	200.1	250.2	300.3	350.4	400.7	450.9
1	0.8	50.8	00.8	50.9	00.9	51.0	01.1	51.3	01.5	51.8
2	1.7	51.7	01.7	51.7	01.8	51.8	01.9	52.1	02.3	52.6
3	2.5	52.5	02.5	52.5	02.6	52.7	02.8	52.9	03.2	53.4
4	3.3	53.3	03.3	53.4	03.4	53.5	03.6	53.8	04.0	54.3
5	4.2	54.2	104.2	154.2	204.3	254.3	304.5	354.6	404.8	455.1
6	5.0	55.0	05.0	55.0	05.1	55.2	05.3	55.5	05.7	56.0
7	5.8	55.8	05.8	55.9	05.9	56.0	06.1	56.3	06.5	56.8
8	6.7	56.7	06.7	56.7	06.8	56.8	07.0	57.1	07.4	57.6
9	7.5	57.5	07.5	57.5	07.6	57.7	07.8	58.0	08.2	58.5
10	8.3	58.3	108.3	158.4	208.4	258.5	308.6	358.8	409.0	459.3
11	9.2	59.2	09.2	59.2	09.3	59.3	09.5	59.6	09.9	60.2
12	10.0	60.0	10.0	60.0	10.1	60.2	10.3	60.5	10 7	61.0
13	10.8	60.8	10.8	60.9	10.9	61.0	11.1	61.3	11.5	61.8
14	11.7	61.7	11.7	61.7	11.8	61.9	12.0	62.2	12.4	62.7
15	12.5	62.5	112.5	162.5	212.6	262.7	312.8	363.0	413.2	463.5
16	13.3	63.3	13.3	63.4	13.4	63.5	13.7	63.8	14.1	64.4
17	14.2	64.2	14.2	64.2	14.3	64.4	14.5	64.7	14.9	65.2
18	15.0	65.0	15.0	65.0	15.1	65.2	15.3	65.5	15.7	66.0
19	15.8	65.8	15.9	65.9	15.9	66.0	16.2	66.3	16.6	66.9
20	16.7	66.7	116.7	166.7	216.8	266.9	317.0	367.2	417.4	467.7
21	17.5	67.5	17.5	67.6	17.6	67.7	17.8	68.0	18.2	68.5
22	18.3	68.3	18.4	68.4	18.4	68.5	18.7	68.8	19.1	69.4
23	19.2	69.2	19.2	69.2	19.3	69.4	19.5	69.7	19.9	70.2
24	20.0	70.0	20.0	70.1	20.1	70.2	20.3	70.5	20.8	71.1
25	20.8	70.8	120.9	170.9	220.9	271.0	321.2	371.4	421.6	471.9
26	21.7	71.7	21.7	71.7	21.8	71.9	22.0	72.2	22.4	72.7
27	22.5	72.5	22.5	72.6	22.6	72.7	22.8	73.0	23.3	73.6
28	23.3	73.3	23.4	73.4	23.4	73.5	23.7	73.9	24.1	74.4
29	24.2	74.2	24.2	74.2	24.3	74.4	24.5	74.7	24.9	75.3
30	25.0	75.0	125.0	175.1	225.1	275.2	325.4	375.5	425.8	476.1
31	25.8	75.8	25.9	75.9	26.0	76.1	26.2	76.4	26.6	76.9
32	26.7	76.7	26.7	76.7	26.8	76.9	27.0	77.2	27.5	77.8
33	27.5	77.5	27.5	77.6	27.6	77.7	27.9	78.1	28.3	78.6
34	28.3	78.3	28.4	78.4	28.5	78.6	28.7	78.9	29.1	79.5
35	29.2	79.2	129.2	179.2	229.3	279.4	329.5	379.7	430.0	480.3
36	30.0	80.0	30.0	80.1	30.1	80.2	30.4	80.6	30.8	81.1
37	30.8	80.8	30.9	80.9	31.0	81.1	31.2	81.4	31.7	82.0
38	31.7	81.7	31.7	81.7	31.8	81.9	32.0	82.2	32.5	82.8
39	32.5	82.5	32.5	82.6	32.6	82.7	32.9	83.1	33.3	83.6
40	33.3	83.3	133.4	183.4	233.5	283.6	333.7	383.9	434.2	484.5
41	34.2	84.2	34.2	84.2	34.3	84.4	34.6	84.7	35.0	85.3
42	35.0	85.0	35.0	85.1	35.1	85.2	35.4	85.6	35.8	86.2
43	35.8	85.8	35.9	85.9	36.0	86.1	36.2	86.4	36.7	87.0
44	36.7	86.7	36.7	86.7	36.8	86.9	37.1	87.3	37.5	87.8
45	37.5	87.5	137.5	187.6	237.6	287.7	337.9	388.1	438.4	488.7
46	38.3	88.3	38.4	88.4	38.5	88.6	38.7	88.9	39.2	89.5
47	39.2	89.2	39.2	89.2	39.3	89.4	39.6	89.8	40.0	90.4
48	40.0	90.0	40.0	90.1	40.1	90.3	40.4	90.6	40.9	91.2
49	40.8	90.8	40.9	90.9	41.0	91.1	41.2	91.4	41.7	92.0
50	41.7	91.7	141.7	191.7	241.8	291.9	342.1	392.3	442.5	492.9
51	42.5	92.5	42.5	92.6	42.6	92.8	42.9	93.1	43.4	93.7
52	43.3	93.3	43.4	93.4	43.5	93.6	43.7	94.0	44.2	94.6
53	44.2	94.2	44.2	94.2	44.3	94.4	44.6	94.8	45.1	95.4
54	45.0	95.0	45.0	95.1	45.2	95.3	45.4	95.6	45.9	96.2
55	45.8	95.8	145.9	195.9	246.0	296.1	346.3	396.5	446.7	497.1
56	46.7	96.7	46.7	96.7	46.8	96.9	47.1	97.3	47.6	97.9
57	47.5	97.5	47.5	97.6	47.7	97.8	47.9	98.1	48.4	98.8
58	48.3	98.3	48.4	98.4	48.5	98.6	48.8	99.0	49.3	99.6
59	49.2	99.2	49.2	99.2	49.3	99.4	49.6	99.8	50.1	500.4
60	50.0	100.0	150.0	200.1	250.2	300.3	350.4	400.7	450.9	501.3
	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE.

°	11°	12°	13°	14°	15°	16°	17°	18°	M.
3	551.7	602.2	652.8	703.5	754.3	805.2	856.3	907.5	0
1	52.5	03.1	53.7	04.4	55.2	06.1	57.2	08.3	1
0	53.4	03.9	54.5	05.2	56.0	06.9	58.0	09.2	2
8	54.2	04.7	55.3	06.1	56.9	07.8	58.9	10.1	3
6	55.1	05.6	56.2	06.9	57.7	08.6	59.7	10.9	4
5	555.9	606.4	657.0	707.7	758.6	809.5	860.6	911.8	5
3	56.7	07.3	57.9	08.6	59.4	10.3	61.4	12.6	6
2	57.6	08.1	58.7	09.4	60.3	11.2	62.3	13.5	7
0	58.4	09.0	59.6	10.3	61.1	12.0	63.1	14.3	8
8	59.3	09.8	60.4	11.1	62.0	12.9	64.0	15.2	9
7	560.1	610.6	661.3	712.0	762.8	813.7	864.8	916.0	10
5	61.0	11.5	62.1	12.8	63.7	14.6	65.7	16.9	11
4	61.8	12.3	62.9	13.7	64.5	15.5	66.5	17.7	12
2	62.6	13.2	63.8	14.5	65.3	16.3	67.4	18.6	13
0	63.5	14.0	64.6	15.4	66.2	17.2	68.2	19.5	14
9	564.3	614.9	665.5	716.2	767.0	818.0	869.1	920.3	15
7	65.2	15.7	66.3	17.1	67.9	18.9	69.9	21.2	16
6	66.0	16.5	67.2	17.9	68.7	19.7	70.8	22.0	17
4	66.8	17.4	68.0	18.7	69.6	20.6	71.6	22.9	18
2	67.7	18.2	68.9	19.6	70.4	21.4	72.5	23.7	19
1	568.5	619.1	669.7	720.4	771.3	822.3	873.3	924.6	20
9	69.4	19.9	70.5	21.3	72.1	23.1	74.2	25.4	21
8	70.2	20.8	71.4	22.1	73.0	24.0	75.1	26.3	22
6	71.1	21.6	72.2	23.0	73.8	24.8	75.9	27.1	23
4	71.9	22.4	73.1	23.8	74.7	25.7	76.8	28.0	24
3	572.7	623.3	673.9	724.7	775.5	826.5	877.6	928.9	25
1	73.6	24.1	74.8	25.5	76.4	27.4	78.5	29.7	26
0	74.4	25.0	75.6	26.4	77.2	28.2	79.3	30.6	27
8	75.3	25.8	76.5	27.2	78.1	29.1	80.2	31.4	28
6	76.1	26.7	77.3	28.1	78.9	29.9	81.0	32.3	29
5	576.9	627.5	678.1	728.9	779.8	830.8	881.9	933.1	30
3	77.8	28.4	79.0	29.8	80.6	31.6	82.7	34.0	31
2	78.6	29.2	79.8	30.6	81.5	32.5	83.6	34.8	32
0	79.5	30.0	80.7	31.4	82.3	33.3	84.4	35.7	33
9	80.3	30.9	81.5	32.3	83.2	34.2	85.3	36.6	34
7	581.2	631.7	682.4	733.1	784.0	835.0	886.1	937.4	35
5	82.0	32.6	83.2	34.0	84.9	35.9	87.0	38.3	36
4	82.8	33.4	84.1	34.8	85.7	36.7	87.9	39.1	37
2	83.7	34.2	84.9	35.7	86.6	37.6	88.7	40.0	38
1	84.5	35.1	85.8	36.5	87.4	38.4	89.6	40.8	39
9	585.4	635.9	686.6	737.4	788.3	839.3	890.4	941.7	40
7	86.2	36.8	87.4	38.2	89.1	40.1	91.3	42.5	41
6	87.0	37.6	88.3	39.1	90.0	41.0	92.1	43.4	42
4	87.9	38.5	89.1	39.9	90.8	41.8	93.0	44.3	43
2	88.7	39.3	90.0	40.8	91.7	42.7	93.8	45.1	44
1	589.6	640.2	690.8	741.6	792.5	843.5	894.7	946.0	45
9	90.4	41.0	91.7	42.5	93.4	44.4	95.5	46.8	46
8	91.3	41.8	92.5	43.3	94.2	45.2	96.4	47.7	47
6	92.1	42.7	93.4	44.2	95.1	46.1	97.2	48.5	48
5	92.9	43.5	94.2	45.0	95.9	46.9	98.1	49.4	49
3	593.8	644.4	695.1	745.8	796.8	847.8	898.9	950.2	50
1	94.6	45.2	95.9	46.7	97.6	48.6	99.8	51.1	51
0	95.5	46.1	96.7	47.5	98.5	49.5	900.7	52.0	52
8	96.3	46.9	97.6	48.4	99.3	50.3	01.5	52.8	53
7	97.2	47.7	98.4	49.2	800.2	51.2	02.4	53.7	54
5	598.0	648.6	699.3	750.1	801.0	852.0	903.2	954.5	55
3	98.8	49.4	700.1	50.9	01.9	52.9	04.1	55.4	56
2	99.7	50.3	01.0	51.8	02.7	53.7	04.9	56.2	57
0	600.5	51.1	01.8	52.6	03.6	54.6	05.8	57.1	58
9	01.4	52.0	02.7	53.5	04.4	55.5	06.6	58.0	59
7	602.2	652.8	703.5	754.3	805.2	856.3	907.5	958.8	60
°	11°	12°	13°	14°	15°	16°	17°	18°	

TABLE III.—TANGENT DISTANCES FOR A I° CURVE.

M.	19°	20°	21°	22°	23°	24°	25°	26°	M.
0	958.8	1010.3	1061.9	1113.7	1165.7	1217.9	1270.2	1322.8	0
1	59.7	11.2	62.8	14.6	66.6	18.7	71.1	23.7	1
2	60.5	12.0	63.7	15.5	67.4	19.6	72.0	24.5	2
3	61.4	12.9	64.5	16.3	68.3	20.5	72.9	25.4	3
4	62.2	13.7	65.4	17.2	69.2	21.4	73.7	26.3	4
5	963.1	1014.6	1066.2	1118.1	1170.1	1222.2	1274.6	1327.2	5
6	64.0	15.4	67.1	18.9	70.9	23.1	75.5	28.1	6
7	64.8	16.3	68.0	19.8	71.8	24.0	76.4	28.9	7
8	65.7	17.2	68.8	20.7	72.7	24.8	77.2	29.8	8
9	66.5	18.0	69.7	21.5	73.5	25.7	78.1	30.7	9
10	967.4	1018.9	1070.6	1122.4	1174.4	1226.6	1279.0	1331.6	10
11	68.2	19.8	71.4	23.2	75.3	27.5	79.9	32.5	11
12	69.1	20.6	72.3	24.1	76.1	28.3	80.7	33.3	12
13	70.0	21.5	73.1	25.0	77.0	29.2	81.6	34.2	13
14	70.8	22.3	74.0	25.8	77.9	30.1	82.5	35.1	14
15	971.7	1023.2	1074.9	1126.7	1178.7	1230.9	1283.4	1336.0	15
16	72.5	24.0	75.7	27.6	79.6	31.8	84.2	36.8	16
17	73.4	24.9	76.6	28.4	80.5	32.7	85.1	37.7	17
18	74.2	25.8	77.5	29.3	81.3	33.6	86.0	38.6	18
19	75.1	26.6	78.3	30.2	82.2	34.4	86.9	39.5	19
20	976.0	1027.5	1079.2	1131.0	1183.1	1235.3	1287.7	1340.4	20
21	76.8	28.3	80.0	31.9	83.9	36.2	88.6	41.2	21
22	77.7	29.2	80.9	32.8	84.8	37.0	89.5	42.1	22
23	78.5	30.1	81.8	33.6	85.7	37.9	90.4	43.0	23
24	79.4	30.9	82.6	34.5	86.6	38.8	91.2	43.9	24
25	980.2	1031.8	1083.5	1135.4	1187.4	1239.7	1292.1	1344.8	25
26	81.1	32.6	84.4	36.2	88.3	40.5	93.0	45.6	26
27	82.0	33.5	85.2	37.1	89.2	41.4	93.9	46.5	27
28	82.8	34.4	86.1	38.0	90.0	42.4	94.7	47.4	28
29	83.7	35.2	86.9	38.8	90.9	43.2	95.6	48.3	29
30	984.5	1036.1	1087.8	1139.7	1191.8	1244.0	1296.5	1349.2	30
31	85.4	37.0	88.7	40.6	92.6	44.9	97.4	50.0	31
32	86.3	37.8	89.5	41.4	93.5	45.8	98.2	50.9	32
33	87.1	38.7	90.4	42.3	94.4	46.6	99.1	51.8	33
34	88.0	39.5	91.3	43.2	95.2	47.5	1300.0	52.7	34
35	988.8	1040.4	1092.1	1144.0	1196.1	1248.4	1300.9	1353.6	35
36	89.7	41.3	93.0	44.9	97.0	49.3	01.7	54.4	36
37	90.5	42.1	93.9	45.8	97.9	50.1	02.6	55.3	37
38	91.4	43.0	94.7	46.6	98.7	51.0	03.5	56.2	38
39	92.3	43.8	95.6	47.5	99.6	51.9	04.4	57.1	39
40	993.1	1044.7	1096.4	1148.4	1200.5	1252.8	1305.3	1358 0	40
41	94.0	45.6	97.3	49.2	01.3	53.6	06.1	58.8	41
42	94.8	46.4	98.2	50.1	02.2	54.5	07.0	59.7	42
43	95.7	47.3	99.0	51.0	03.1	55.4	07.9	60.6	43
44	96.5	48.1	99.9	51.8	03.9	56.3	08.8	61.5	44
45	997.4	1049.0	1100.8	1152.7	1204.8	1257.1	1309.6	1362.4	45
46	98.3	49.9	01.6	53.6	05.7	58.0	10.5	63.2	46
47	99.1	50.7	02.5	54.4	06.6	58.9	11.4	64.1	47
48	1000.0	51.6	03.4	55.3	07.4	59.7	12.3	65.0	48
49	00.8	52.4	04.2	56.2	08.3	60.6	13.1	65.9	49
50	1001.7	1053.3	1105.1	1157.0	1209.2	1261.5	1314.0	1366.8	50
51	02.6	54.2	05.9	57.9	10.0	62.4	14.9	67.6	51
52	03.4	55.0	06.8	58.8	10.9	63.2	15.8	68.5	52
53	04.3	55.9	07.7	59.6	11.8	64.1	16.7	69.4	53
54	05.1	56.8	08.5	60.5	12.7	65.0	17.5	70.3	54
55	1006.0	1057.6	1109.4	1161.4	1213.5	1265.9	1318.4	1371.2	55
56	06.9	58.5	10.3	62.2	14.4	66.7	19.3	72.0	56
57	07.7	59.3	11.1	63.1	15.3	67.6	20.2	72.9	57
58	08.6	60.2	12.0	64.0	16.1	68.5	21.0	73.8	58
59	09.4	61.1	12.9	64.8	17.0	69.4	21.9	74.7	59
60	1010.3	1061.9	1113.7	1165.7	1217.9	1270.2	1322.8	1375.6	60
	19°	20°	21°	22°	23°	24°	25°	26°	

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE.

27°	28°	29°	30°	31°	32°	33°	34°	M.
1375.6	1428.6	1481.8	1535.3	1589.0	1643.0	1697.2	1751.7	0
76.4	29.4	82.7	36.1	89.9	43.9	98.1	52.6	1
77.3	30.3	83.6	37.0	90.8	44.8	99.0	53.6	2
78.2	31.2	84.5	37.9	91.7	45.7	99.9	54.5	3
79.1	32.1	85.3	38.8	92.6	46.6	1700.8	55.4	4
1380.0	1433.0	1486.2	1539.7	1593.5	1647.5	1701.7	1756.3	5
80.9	33.9	87.1	40.6	94.4	48.4	02.6	57.2	6
81.7	34.8	88.0	41.5	95.3	49.3	03.5	58.1	7
82.6	35.6	88.9	42.4	96.2	50.2	04.5	59.0	8
83.5	36.5	89.8	43.3	97.1	51.1	05.4	59.9	9
1384.4	1437.4	1490.7	1544.2	1598.0	1652.0	1706.3	1760.8	10
85.3	38.3	91.6	45.1	98.8	52.9	07.2	61.8	11
86.1	39.2	92.5	46.0	99.7	53.8	08.1	62.7	12
87.0	40.1	93.4	46.9	1600.6	54.7	09.0	63.6	13
87.9	41.0	94.2	47.8	01.5	55.6	09.9	64.5	14
1388.8	1441.8	1495.1	1548.7	1602.4	1656.5	1710.8	1765.4	15
89.7	42.7	96.0	49.6	03.3	57.4	11.7	66.3	16
90.6	43.6	96.9	50.4	04.2	58.3	12.6	67.2	17
91.4	44.5	97.8	51.3	05.1	59.2	13.5	68.1	18
92.3	45.4	98.7	52.2	06.0	60.1	14.4	69.1	19
1393.2	1446.3	1499.6	1553.1	1606.9	1661.0	1715.3	1770.0	20
94.1	47.2	1500.5	54.0	07.8	61.9	16.3	70.9	21
95.0	48.1	01.4	54.9	08.7	62.8	17.2	71.8	22
95.9	48.9	02.3	55.8	09.6	63.7	18.1	72.7	23
96.7	49.8	03.1	56.7	10.5	64.6	19.0	73.6	24
1397.6	1450.7	1504.0	1557.6	1611.4	1665.5	1719.9	1774.5	25
98.5	51.6	04.9	58.5	12.3	66.4	20.8	75.4	26
99.4	52.5	05.8	59.4	13.2	67.3	21.7	76.4	27
1400.3	53.4	06.7	60.3	14.1	68.2	22.6	77.3	28
01.2	54.3	07.6	61.2	15.0	69.1	23.5	78.2	29
1402.0	1455.1	1508.5	1562.1	1615.9	1670.0	1724.4	1779.1	30
02.9	56.0	09.4	63.0	16.8	70.9	25.3	80.0	31
03.8	56.9	10.3	63.9	17.7	71.8	26.2	80.9	32
04.7	57.8	11.2	64.8	18.6	72.8	27.2	81.8	33
05.6	58.7	12.1	65.7	19.5	73.7	28.1	82.8	34
1406.5	1459.6	1512.9	1566.6	1620.4	1674.6	1729.0	1783.7	35
07.3	60.5	13.8	67.5	21.3	75.5	29.9	84.6	36
08.2	61.4	14.7	68.4	22.2	76.4	30.8	85.5	37
09.1	62.2	15.6	69.2	23.1	77.3	31.7	86.4	38
10.0	63.1	16.5	70.1	24.0	78.2	32.6	87.3	39
1410.9	1464.0	1517.4	1571.0	1624.9	1679.1	1733.5	1788.2	40
11.8	64.9	18.3	71.9	25.8	80.0	34.4	89.2	41
12.6	65.8	19.2	72.8	26.7	80.9	35.3	90.1	42
13.5	66.7	20.1	73.7	27.6	81.8	36.3	91.0	43
14.4	67.6	21.0	74.6	28.5	82.7	37.2	91.9	44
1415.3	1468.5	1521.9	1575.5	1629.4	1683.6	1738.1	1792.8	45
16.2	69.3	22.8	76.4	30.3	84.5	39.0	93.7	46
17.1	70.2	23.6	77.3	31.2	85.4	39.9	94.6	47
17.9	71.1	24.5	78.2	32.1	86.3	40.8	95.6	48
18.8	72.0	25.4	79.1	33.0	87.2	41.7	96.5	49
1419.7	1472.9	1526.3	1580.0	1633.9	1688.1	1742.6	1797.4	50
20.6	73.8	27.2	80.9	34.8	89.1	43.5	98.3	51
21.5	74.7	28.1	81.8	35.7	90.0	44.4	99.2	52
22.4	75.6	29.0	82.7	36.6	90.9	45.4	1800.1	53
23.3	76.5	29.9	83.6	37.5	91.8	46.3	01.1	54
1424.1	1477.3	1530.8	1584.5	1638.4	1692.7	1747.2	1802.0	55
25.0	78.2	31.7	85.4	39.3	93.6	48.1	02.9	56
25.9	79.1	32.6	86.3	40.2	94.5	49.0	03.8	57
26.8	80.0	33.5	87.2	41.1	95.4	49.9	04.7	58
27.7	80.9	34.4	88.1	42.0	96.3	50.8	05.6	59
1428.6	1481.8	1535.3	1589.0	1643.0	1697.2	1751.7	1806.6	60
27°	28°	29°	30°	31°	32°	33°	34°	

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE

M.	35°	36°	37°	38°	39°	40°	41°	4
0	1806.6	1861.7	1917.1	1972.9	2029.0	2085.4	2142.2	21
1	07.5	62.6	18.0	73.8	29.9	86.4	43.2	22
2	08.4	63.5	19.0	74.7	30.9	87.3	44.1	
3	09.3	64.4	19.9	75.7	31.8	88.3	45.1	
4	10.2	65.4	20.8	76.6	32.7	89.2	46.0	
5	1811.1	1866.3	1921.7	1977.5	2033.7	2090.1	2147.0	22
6	12.1	67.2	22.7	78.5	34.6	91.1	47.9	
7	13.0	68.1	23.6	79.4	35.5	92.0	48.9	
8	13.9	69.0	24.5	80.3	36.5	93.0	49.8	
9	14.8	70.0	25.5	81.3	37.4	93.9	50.8	
10	1815.7	1870.9	1926.4	1982.2	2038.4	2094.9	2151.7	22
11	16.6	71.8	27.3	83.1	39.3	95.8	52.7	
12	17.6	72.7	28.2	84.1	40.2	96.8	53.6	
13	18.5	73.7	29.2	85.0	41.2	97.7	54.6	
14	19.4	74.6	30.1	85.9	42.1	98.6	55.5	
15	1820.3	1875.5	1931.0	1986.9	2043.1	2099.6	2156.5	22
16	21.2	76.4	32.0	87.8	44.0	2100.5	57.4	
17	22.1	77.4	32.9	88.7	44.9	01.5	58.4	
18	23.1	78.3	33.8	89.7	45.9	02.4	59.3	
19	24.0	79.2	34.7	90.6	46.8	03.4	60.3	
20	1824.9	1880.1	1935.7	1991.5	2047.8	2104.3	2161.2	22
21	25.8	81.0	36.6	92.5	48.7	05.3	62.2	
22	26.7	82.0	37.5	93.4	49.6	06.2	63.2	
23	27.6	82.9	38.5	94.3	50.6	07.2	64.1	
24	28.6	83.8	39.4	95.3	51.5	08.1	65.1	
25	1829.5	1884.7	1940.3	1996.2	2052.5	2109.0	2166.0	22
26	30.4	85.7	41.2	97.1	53.4	10.0	67.0	
27	31.3	86.6	42.2	98.1	54.3	10.9	67.9	
28	32.2	87.5	43.1	99.0	55.3	11.9	68.9	
29	33.2	88.4	44.0	99.9	56.2	12.8	69.8	
30	1834.1	1889.4	1945.0	2000.9	2057.2	2113.8	2170.8	22
31	35.0	90.3	45.9	01.8	58.1	14.7	71.7	
32	35.9	91.2	46.8	02.8	59.0	15.7	72.7	
33	36.8	92.1	47.7	03.7	60.0	16.6	73.6	
34	37.8	93.1	48.7	04.6	60.9	17.6	74.6	
35	1838.7	1894.0	1949.6	2005.6	2061.9	2118.5	2175.5	22
36	39.6	94.9	50.5	06.5	62.8	19.5	76.5	
37	40.5	95.8	51.5	07.4	63.7	20.4	77.4	
38	41.4	96.7	52.4	08.4	64.7	21.4	78.4	
39	42.4	97.7	53.3	09.3	65.6	22.3	79.4	
40	1843.3	1898.6	1954.3	2010.2	2066.6	2123.3	2180.3	22
41	44.2	99.5	55.2	11.2	67.5	24.2	81.3	
42	45.1	1900.4	56.1	12.1	68.5	25.1	82.2	
43	46.0	01.4	57.0	13.0	69.4	26.1	83.2	
44	47.0	02.3	58.0	14.0	70.3	27.0	84.1	
45	1847.9	1903.2	1958.9	2014.9	2071.3	2128.0	2185.1	22
46	48.8	04.2	59.8	15.9	72.2	28.9	86.0	
47	49.7	05.1	60.8	16.8	73.2	29.9	87.0	
48	50.6	06.0	61.7	17.7	74.1	30.8	87.9	
49	51.5	06.9	62.6	18.7	75.0	31.8	88.9	
50	1852.5	1907.9	1963.6	2019.6	2076.0	2132.7	2189.9	22
51	53.4	08.8	64.5	20.5	76.9	33.7	90.8	
52	54.3	09.7	65.4	21.5	77.9	34.6	91.8	
53	55.2	10.6	66.4	22.4	78.8	35.6	92.7	
54	56.2	11.6	67.3	23.4	79.8	36.5	93.7	
55	1857.1	1912.5	1968.2	2024.3	2080.7	2137.5	2194.6	23
56	58.0	13.4	69.1	25.2	81.6	38.4	95.6	
57	58.9	14.3	70.1	26.2	82.6	39.4	96.5	
58	59.8	15.3	71.0	27.1	83.5	40.3	97.5	
59	60.8	16.2	71.9	28.0	84.5	41.3	98.5	
60	*1861.7*	1917.1	1972.9	2029.0	2085.4	2142.2	2199.4	23
	35°	*36°*	*37°*	*38°*	*39°*	*40°*	*41°*	

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE.

43°	44°	45°	46°	47°	48°	49°	50°	M.
2257.0	2314.9	2373.3	2432.1	2491.3	2551.0	2611.2	2671.8	0
57.9	15.9	74.3	33.1	92.3	52.0	12.2	72.8	1
58.9	16.9	75.3	34.1	93.3	53.0	13.2	73.8	2
59.9	17.8	76.2	35.0	94.3	54.0	14.2	74.8	3
60.8	18.8	77.2	36.0	95.3	55.0	15.2	75.8	4
2261.8	2319.8	2378.2	2437.0	2496.3	2556.0	2616.2	2676.9	5
62.7	20.7	79.2	38.0	97.3	57.0	17.2	77.9	6
63.7	21.7	80.1	39.0	98.3	58.0	18.2	78.9	7
64.7	22.7	81.1	40.0	99.3	59.0	19.2	79.9	8
65.6	23.7	82.1	40.9	2500.2	60.0	20.2	80.9	9
2266.6	2324.6	2383.1	2441.9	2501.2	2561.0	2621.2	2681.9	10
67.6	25.6	84.0	42.9	02.2	62.0	22.2	82.9	11
68.5	26.6	85.0	43.9	03.2	63.0	23.2	84.0	12
69.5	27.5	86.0	44.9	04.2	64.0	24.2	85.0	13
70.5	28.5	87.0	45.9	05.2	65.0	25.3	86.0	14
2271.4	2329.5	2388.0	2446.9	2506.2	2566.0	2626.3	2687.0	15
72.4	30.5	88.9	47.8	07.2	67.0	27.3	88.0	16
73.4	31.4	89.9	48.8	08.2	68.0	28.3	89.0	17
74.3	32.4	90.9	49.8	09.2	69.0	29.3	90.1	18
75.3	33.4	91.9	50.8	10.2	70.0	30.3	91.1	19
2276.2	2334.3	2392.8	2451.8	2511.2	2571.0	2631.3	2692.1	20
77.2	35.3	93.8	52.8	12.2	72.0	32.3	93.1	21
78.2	36.3	94.8	53.8	13.2	73.0	33.3	94.1	22
79.1	37.3	95.8	54.7	14.1	74.0	34.3	95.2	23
80.1	38.2	96.8	55.7	15.1	75.0	35.3	96.2	24
2281.1	2339.2	2397.7	2456.7	2516.1	2576.0	2636.4	2697.2	25
82.0	40.2	98.7	57.7	17.1	77.0	37.4	98.2	26
83.0	41.1	99.7	58.7	18.1	78.0	38.4	99.2	27
84.0	42.1	2400.7	59.7	19.1	79.0	39.4	2700.2	28
84.9	43.1	01.7	60.7	20.1	80.0	40.4	01.3	29
2285.9	2344.1	2402.6	2461.7	2521.1	2581.0	2641.4	2702.3	30
86.9	45.0	03.6	62.6	22.1	82.0	42.4	03.3	31
87.8	46.0	04.6	63.6	23.1	83.0	43.4	04.3	32
88.8	47.0	05.6	64.6	24.1	84.0	44.4	05.3	33
89.8	48.0	06.6	65.6	25.1	85.0	45.4	06.4	34
2290.7	2348.9	2407.5	2466.6	2526.1	2586.0	2646.5	2707.4	35
91.7	49.9	08.5	67.6	27.1	87.0	47.5	08.4	36
92.7	50.9	09.5	68.6	28.1	88.0	48.5	09.4	37
93.6	51.8	10.5	69.6	29.1	89.0	49.5	10.4	38
94.6	52.8	11.5	70.5	30.1	90.0	50.5	11.5	39
2295.6	2353.8	2412.4	2471.5	2531.1	2591.1	2651.5	2712.5	40
96.5	54.8	13.4	72.5	32.1	92.1	52.5	13.5	41
97.5	55.7	14.4	73.5	33.1	93.1	53.5	14.5	42
98.5	56.7	15.4	74.5	34.1	94.1	54.6	15.5	43
99.4	57.7	16.4	75.5	35.0	95.1	55.6	16.6	44
2300.4	2358.7	2417.4	2476.5	2536.0	2596.1	2656.6	2717.6	45
01.4	59.6	18.3	77.5	37.0	97.1	57.6	18.6	46
02.3	60.6	19.3	78.5	38.0	98.1	58.6	19.6	47
03.3	61.6	20.3	79.4	39.0	99.1	59.6	20.6	48
04.3	62.6	21.3	80.4	40.0	2600.1	60.6	21.7	49
2305.2	2363.5	2422.3	2481.4	2541.0	2601.1	2661.6	2722.7	50
06.2	64.5	23.2	82.4	42.0	02.1	62.7	23.7	51
07.2	65.5	24.2	83.4	43.0	03.1	63.7	24.7	52
08.1	66.5	25.2	84.4	44.0	04.1	64.7	25.7	53
09.1	67.4	26.2	85.4	45.0	05.1	65.7	26.8	54
2310.1	2368.4	2427.2	2486.4	2546.0	2606.1	2666.7	2727.8	55
11.1	69.4	28.2	87.4	47.0	07.1	67.7	28.8	56
12.0	70.4	29.1	88.4	48.0	08.1	68.7	29.8	57
13.0	71.3	30.1	89.3	49.0	09.1	69.8	30.9	58
14.0	72.3	31.1	90.3	50.0	10.1	70.8	31.9	59
2314.9	2373.3	2432.1	2491.3	2551.0	2611.2	2671.8	2732.9	60
43°	44°	45°	46°	47°	48°	49°	50°	

M.	51°	52°	53°	54°	55°	56°	57°	58
0	2732.9	2794.5	2856.7	2919.4	2982.7	3046.5	3110.9	317
1	33.9	95.6	57.7	20.5	83.7	47.6	12.0	7
2	34.9	96.6	58.8	21.5	84.8	48.6	13.1	7
3	36.0	97.6	59.8	22.6	85.8	49.7	14.2	7
4	37.0	98.7	60.9	23.6	86.9	50.8	15.3	8
5	2738.0	2799.7	2861.9	2924.7	2988.0	3051.9	3116.3	318
6	39.0	2800.7	62.9	25.7	89.0	52.9	17.4	8
7	40.1	01.8	64.0	26.8	90.1	54.0	18.5	8
8	41.1	02.8	65.0	27.8	91.1	55.1	19.6	8
9	42.1	03.8	66.1	28.9	92.2	56.1	20.7	8
10	2743.1	2804.9	2867.1	2929.9	2993.3	3057.2	3121.7	318
11	44.2	05.9	68.2	31.0	94.3	58.3	22.8	8
12	45.2	06.9	69.2	32.0	95.4	59.3	23.9	8
13	46.2	08.0	70.2	33.1	96.5	60.4	25.0	9
14	47.2	09.0	71.3	34.1	97.5	61.5	26.1	9
15	2748.3	2810.0	2872.3	2935.2	2998.6	3062.6	3127.2	319
16	49.3	11.1	73.4	36.2	99.6	63.6	28.2	9
17	50.3	12.1	74.4	37.3	3000.7	64.7	29.3	9
18	51.3	13.1	75.5	38.3	01.8	65.8	30.4	9
19	52.4	14.2	76.5	39.4	02.8	66.8	31.5	9
20	2753.4	2815.2	2877.5	2940.4	3003.9	3067.9	3132.6	319
21	54.4	16.2	78.6	41.5	04.9	69.0	33.6	9
22	55.4	17.3	79.6	42.5	06.0	70.1	34.7	320
23	56.5	18.3	80.7	43.6	07.1	71.1	35.8	0
24	57.5	19.3	81.7	44.6	08.1	72.2	36.9	0
25	2758.5	2820.4	2882.8	2945.7	3009.2	3073.3	3138.0	320
26	59.5	21.4	83.8	46.7	10.3	74.4	39.1	0
27	60.6	22.4	84.8	47.8	11.3	75.4	40.1	0
28	61.6	23.5	85.9	48.9	12.4	76.5	41.2	0
29	62.6	24.5	86.9	49.9	13.5	77.6	42.3	0
30	2763.7	2825.6	2888.0	2951.0	3014.5	3078.7	3143.4	320
31	64.7	26.6	89.0	52.0	15.6	79.7	44.5	0
32	65.7	27.6	90.1	53.1	16.6	80.8	45.6	1
33	66.7	28.7	91.1	54.1	17.7	81.9	46.6	1
34	67.8	29.7	92.2	55.2	18.8	82.9	47.7	1
35	2768.8	2830.7	2893.2	2956.2	3019.8	3084.0	3148.8	321
36	69.8	31.8	94.3	57.3	20.9	85.1	49.9	1
37	70.8	32.8	95.3	58.3	22.0	86.2	51.0	1
38	71.9	33.8	96.4	59.4	23.0	87.2	52.1	1
39	72.9	34.9	97.4	60.5	24.1	88.3	53.2	1
40	2773.9	2835.9	2898.4	2961.5	3025.2	3089.4	3154.2	321
41	75.0	37.0	99.5	62.6	26.2	90.5	55.3	2
42	76.0	38.0	2900.5	63.6	27.3	91.6	56.4	2
43	77.0	39.0	01.6	64.7	28.4	92.6	57.5	2
44	78.1	40.1	02.6	65.7	29.4	93.7	58.6	2
45	2779.1	2841.1	2903.7	2966.8	3030.5	3094.8	3159.7	322
46	80.1	42.1	04.7	67.9	31.6	95.9	60.8	2
47	81.1	43.2	05.8	68.9	32.6	96.9	61.8	2
48	82.2	44.2	06.8	70.0	33.7	98.0	62.9	2
49	83.2	45.3	07.9	71.0	34.8	99.1	64.0	2
50	2784.2	2846.3	2908.9	2972.1	3035.8	3100.2	3165.1	323
51	85.3	47.3	10.0	73.1	36.9	01.2	66.2	3
52	86.3	48.4	11.0	74.2	38.0	02.3	67.3	3
53	87.3	49.4	12.1	75.3	39.0	03.4	68.4	3
54	88.4	50.5	13.1	76.3	40.1	04.5	69.5	3
55	2789.4	2851.5	2914.2	2977.4	3041.2	3105.6	3170.6	323
56	90.4	52.5	15.2	78.4	42.2	06.6	71.6	3
57	91.4	53.6	16.3	79.5	43.3	07.7	72.7	3
58	92.5	54.6	17.3	80.5	44.4	08.8	73.8	3
59	93.5	55.7	18.4	81.6	45.4	09.9	74.9	4
60	2794.5	2856.7	2919.4	2982.7	3046.5	3110.9	3176.0	324
	51°	52°	53°	54°	55°	56°	57°	58

BLE III.—TANGENT DISTANCES FOR A 1° CURVE.

44°	45°	46°	47°	48°	49°	50°	M.
2314.9	2373.3	2432.1	2491.3	2551.0	2611.2	2671.8	0
15.9	74.3	33.1	92.3	52.0	12.2	72.8	1
16.9	75.3	34.1	93.3	53.0	13.2	73.8	2
17.8	76.2	35.0	94.3	54.0	14.2	74.8	3
18.8	77.2	36.0	95.3	55.0	15.2	75.8	4
2319.8	2378.2	2437.0	2496.3	2556.0	2616.2	2676.9	5
20.7	79.2	38.0	97.3	57.0	17.2	77.9	6
21.7	80.1	39.0	98.3	58.0	18.2	78.9	7
22.7	81.1	40.0	99.3	59.0	19.2	79.9	8
23.7	82.1	40.9	2500.2	60.0	20.2	80.9	9
2324.6	2383.1	2441.9	2501.2	2561.0	2621.2	2681.9	10
25.6	84.0	42.9	02.2	62.0	22.2	82.9	11
26.6	85.0	43.9	03.2	63.0	23.2	84.0	12
27.5	86.0	44.9	04.2	64.0	24.2	85.0	13
28.5	87.0	45.9	05.2	65.0	25.3	86.0	14
2329.5	2388.0	2446.9	2506.2	2566.0	2626.3	2687.0	15
30.5	88.9	47.8	07.2	67.0	27.3	88.0	16
31.4	89.9	48.8	08.2	68.0	28.3	89.0	17
32.4	90.9	49.8	09.2	69.0	29.3	90.1	18
33.4	91.9	50.8	10.2	70.0	30.3	91.1	19
2334.3	2392.8	2451.8	2511.2	2571.0	2631.3	2692.1	20
35.3	93.8	52.8	12.2	72.0	32.3	93.1	21
36.3	94.8	53.8	13.2	73.0	33.3	94.1	22
37.3	95.8	54.7	14.1	74.0	34.3	95.2	23
38.2	96.8	55.7	15.1	75.0	35.3	96.2	24
2339.2	2397.7	2456.7	2516.1	2576.0	2636.4	2697.2	25
40.2	98.7	57.7	17.1	77.0	37.4	98.2	26
41.1	99.7	58.7	18.1	78.0	38.4	99.2	27
42.1	2400.7	59.7	19.1	79.0	39.4	2700.2	28
43.1	01.7	60.7	20.1	80.0	40.4	01.3	29
2344.1	2402.6	2461.7	2521.1	2581.0	2641.4	2702.3	30
45.0	03.6	62.6	22.1	82.0	42.4	03.3	31
46.0	04.6	63.6	23.1	83.0	43.4	04.3	32
47.0	05.6	64.6	24.1	84.0	44.4	05.3	33
48.0	06.6	65.6	25.1	85.0	45.4	06.4	34
2348.9	2407.5	2466.6	2526.1	2586.0	2646.5	2707.4	35
49.9	08.5	67.6	27.1	87.0	47.5	08.4	36
50.9	09.5	68.6	28.1	88.0	48.5	09.4	37
51.8	10.5	69.6	29.1	89.0	49.5	10.4	38
52.8	11.5	70.5	30.1	90.0	50.5	11.5	39
2353.8	2412.4	2471.5	2531.1	2591.1	2651.5	2712.5	40
54.8	13.4	72.5	32.1	92.1	52.5	13.5	41
55.7	14.4	73.5	33.1	93.1	53.5	14.5	42
56.7	15.4	74.5	34.1	94.1	54.6	15.5	43
57.7	16.4	75.5	35.0	95.1	55.6	16.6	44
2358.7	2417.4	2476.5	2536.0	2596.1	2656.6	2717.6	45
59.6	18.3	77.5	37.0	97.1	57.6	18.6	46
60.6	19.3	78.5	38.0	98.1	58.6	19.6	47
61.6	20.3	79.4	39.0	99.1	59.6	20.6	48
62.6	21.3	80.4	40.0	2600.1	60.6	21.7	49
2363.5	2422.3	2481.4	2541.0	2601.1	2661.6	2722.7	50
64.5	23.2	82.4	42.0	02.1	62.7	23.7	51
65.5	24.2	83.4	43.0	03.1	63.7	24.7	52
66.5	25.2	84.4	44.0	04.1	64.7	25.7	53
67.4	26.2	85.4	45.0	05.1	65.7	26.8	54
2368.4	2427.2	2486.4	2546.0	2606.1	2666.7	2727.8	55
69.4	28.2	87.4	47.0	07.1	67.7	28.8	56
70.4	29.1	88.4	48.0	08.1	68.7	29.8	57
71.3	30.1	89.3	49.0	09.1	69.8	30.9	58
72.3	31.1	90.3	50.0	10.1	70.8	31.9	59
2373.3	*2432.1*	*2491.3*	2551.0	2611.2	2671.8	2732.9	60
44°	45°	46°	47°	48°	49°	50°	

M.	67°	68°	69°	70°	71°	72°	73°
0	3792.4	3864.7	3937.9	4011.9	4086.9	4162.8	4239.7
1	93.6	65.9	39.1	13.2	88.2	64.1	41.0
2	94.8	67.1	40.3	14.4	89.4	65.4	42.3
3	96.0	68.3	41.6	15.7	90.7	66.7	43.6
4	97.2	69.6	42.8	16.9	92.0	67.9	44.9
5	3798.4	3870.8	3944.0	4018.2	4093.2	4169.2	4246.2
6	99.6	72.0	45.2	19.4	94.5	70.5	47.5
7	3800.8	73.2	46.5	20.6	95.7	71.8	48.8
8	02.0	74.4	47.7	21.9	97.0	73.0	50.0
9	03.2	75.6	48.9	23.1	98.2	74.3	51.3
10	3804.4	3876.8	3950.2	4024.4	4099.5	4175.6	4252.6
11	05.6	78.0	51.4	25.6	4100.8	76.9	53.9
12	06.8	79.3	52.6	26.9	02.0	78.1	55.2
13	08.0	80.5	53.9	28.1	03.3	79.4	56.5
14	09.2	81.7	55.1	29.4	04.5	80.7	57.8
15	3810.4	3882.9	3956.3	4030.6	4105.8	4182.0	4259.1
16	11.6	84.1	57.5	31.8	07.1	83.2	60.4
17	12.8	85.3	58.8	33.1	08.3	84.5	61.7
18	14.0	86.6	60.0	34.3	09.6	85.8	63.0
19	15.2	87.8	61.2	35.6	10.9	87.1	64.3
20	3816.4	3889.0	3962.5	4036.8	4112.1	4188.4	4265.6
21	17.6	90.2	63.7	38.1	13.4	89.6	66.9
22	18.8	91.4	64.9	39.3	14.6	90.9	68.2
23	20.0	92.6	66.2	40.6	15.9	92.2	69.5
24	21.2	93.9	67.4	41.8	17.2	93.5	70.7
25	3822.4	3895.1	3968.6	4043.1	4118.4	4194.8	4272.0
26	23.6	96.3	69.9	44.3	19.7	96.0	73.3
27	24.8	97.5	71.1	45.6	21.0	97.3	74.6
28	26.0	98.7	72.3	46.8	22.2	98.6	75.9
29	27.2	3900.0	73.6	48.1	23.5	99.9	77.2
30	3828.4	3901.2	3974.8	4049.3	4124.8	4201.2	4278.5
31	29.6	02.4	76.0	50.6	26.0	02.4	79.8
32	30.8	03.6	77.3	51.8	27.3	03.7	81.1
33	32.0	04.8	78.5	53.1	28.6	05.0	82.4
34	33.3	06.1	79.7	54.3	29.8	06.3	83.7
35	3834.5	3907.3	3981.0	4055.6	4131.1	4207.6	4285.0
36	35.7	08.5	82.2	56.8	32.4	08.8	86.3
37	36.9	09.7	83.4	58.1	33.6	10.1	87.6
38	38.1	10.9	84.7	59.3	34.9	11.4	88.9
39	39.3	12.2	85.9	60.6	36.2	12.7	90.2
40	3840.5	3913.4	3987.2	4061.8	4137.4	4214.0	4291.5
41	41.7	14.6	88.4	63.1	38.7	15.3	92.8
42	42.9	15.8	89.6	64.3	40.0	16.5	94.1
43	44.1	17.1	90.9	65.6	41.2	17.8	95.4
44	45.3	18.3	92.1	66.8	42.5	19.1	96.7
45	3846.5	3919.5	3993.3	4068.1	4143.8	4220.4	4298.0
46	47.7	20.7	94.6	69.3	45.0	21.7	99.3
47	49.0	21.9	95.8	70.6	46.3	23.0	4300.6
48	50.2	23.2	97.1	71.9	47.6	24.3	01.9
49	51.4	24.4	98.3	73.1	48.8	25.5	03.2
50	3852.6	3925.6	3999.5	4074.4	4150.1	4226.8	4304.6
51	53.8	26.8	4000.8	75.6	51.4	28.1	05.9
52	55.0	28.1	02.0	76.9	52.7	29.4	07.2
53	56.2	29.3	03.3	78.1	53.9	30.7	08.5
54	57.4	30.5	04.5	79.4	55.2	32.0	09.8
55	3858.6	3931.7	4005.7	4080.6	4156.5	4233.3	4311.1
56	59.9	33.0	07.0	81.9	57.7	34.6	12.4
57	61.1	34.2	08.2	83.1	59.0	35.9	13.7
58	62.3	35.4	09.5	84.4	60.3	37.1	15.0
59	63.5	36.7	10.7	85.7	61.6	38.4	16.3
60	3864.7	3937.9	4011.9	4086.9	4162.8	4239.7	4317.6
	67°	68°	69°	70°	71°	72°	73°

75°	76°	77°	78°	79°	80°	81°	82°	M.
4396.5	4476.5	4557.6	4639.8	4723.2	4807.7	4893.6	4980.7	0
97.8	77.8	58.9	41.2	24.6	09.2	95.0	82.2	1
99.2	79.2	60.3	42.5	26.0	10.6	96.5	83.6	2
4400.5	80.5	61.7	43.9	27.4	12.0	97.9	85.1	3
01.8	81.9	63.0	45.3	28.8	13.4	99.4	86.6	4
4403.1	4483.2	4564.4	4646.7	4730.2	4814.9	4900.8	4988.0	5
04.5	84.6	65.7	48.1	31.6	16.3	02.2	89.5	6
05.8	85.9	67.1	49.4	33.0	17.7	03.7	91.0	7
07.1	87.2	68.5	50.8	34.4	19.1	05.1	92.4	8
08.4	88.6	69.8	52.2	35.8	20.5	06.6	93.9	9
4409.8	4489.9	4571.2	4653.6	4737.2	4822.0	4908.0	4995.4	10
11.1	91.3	72.6	55.0	38.6	23.4	09.5	96.8	11
12.4	92.6	73.9	56.4	40.0	24.8	10.9	98.3	12
13.8	94.0	75.3	57.7	41.4	26.2	12.4	99.8	13
15.1	95.3	76.6	59.1	42.8	27.7	13.8	5001.2	14
4416.4	4496.7	4578.0	4660.5	4744.2	4829.1	4915.2	5002.7	15
17.7	98.0	79.4	61.9	45.6	30.5	16.7	04.2	16
19.1	99.4	80.7	63.3	47.0	31.9	18.1	05.6	17
20.4	4500.7	82.1	64.7	48.4	33.4	19.6	07.1	18
21.7	02.0	83.5	66.1	49.8	34.8	21.0	08.6	19
4423.1	4503.4	4584.8	4667.4	4751.2	4836.2	4922.5	5010.0	20
24.4	04.7	86.2	68.8	52.6	37.6	23.9	11.5	21
25.7	06.1	87.6	70.2	54.0	39.1	25.4	13.0	22
27.0	07.4	89.0	71.6	55.4	40.5	26.8	14.5	23
28.4	08.8	90.3	73.0	56.8	41.9	28.3	15.9	24
4429.7	4510.1	4591.7	4674.4	4758.3	4843.4	4929.7	5017.4	25
31.0	11.5	93.1	75.8	59.7	44.8	31.2	18.9	26
32.4	12.8	94.4	77.2	61.1	46.2	32.6	20.3	27
33.7	14.2	95.8	78.5	62.5	47.6	34.1	21.8	28
35.0	15.5	97.2	79.9	63.9	49.1	35.5	23.3	29
4436.4	4516.9	4598.5	4681.3	4765.3	4850.5	4937.0	5024.8	30
37.7	18.2	99.9	82.7	66.7	51.9	38.4	26.2	31
39.0	19.6	4601.3	84.1	68.1	53.4	39.9	27.7	32
40.4	20.9	02.6	85.5	69.5	54.8	41.3	29.2	33
41.7	22.3	04.0	86.9	70.9	56.2	42.8	30.7	34
4443.0	4523.7	4605.4	4688.3	4772.4	4857.7	4944.2	5032.1	35
44.4	25.0	06.8	89.7	73.8	59.1	45.7	33.6	36
45.7	26.4	08.1	91.1	75.2	60.5	47.2	35.1	37
47.0	27.7	09.5	92.4	76.6	62.0	48.6	36.6	38
48.4	29.1	10.9	93.8	78.0	63.4	50.1	38.1	39
4449.7	4530.4	4612.2	4695.2	4779.4	4864.8	4951.5	5039.5	40
51.1	31.8	13.6	96.6	80.8	66.3	53.0	41.0	41
52.4	33.1	15.0	98.0	82.2	67.7	54.4	42.5	42
53.7	34.5	16.4	99.4	83.7	69.1	55.9	44.0	43
55.1	35.8	17.7	4700.8	85.1	70.6	57.3	45.4	44
4456.4	4537.2	4619.1	4702.2	4786.5	4872.0	4958.8	5046.9	45
57.7	38.6	20.5	03.6	87.9	73.4	60.3	48.4	46
59.1	39.9	21.9	05.0	89.3	74.9	61.7	49.9	47
60.4	41.3	23.2	06.4	90.7	76.3	63.2	51.4	48
61.7	42.6	24.6	07.8	92.1	77.8	64.6	52.8	49
4463.1	4544.0	4626.0	4709.2	4793.6	4879.2	4966.1	5054.3	50
64.4	45.3	27.4	10.6	95.0	80.6	67.6	55.8	51
65.8	46.7	28.8	12.0	96.4	82.1	69.0	57.3	52
67.1	48.1	30.1	13.4	97.8	83.5	70.5	58.8	53
68.4	49.4	31.5	14.8	99.2	84.9	71.9	60.3	54
4469.8	4550.8	4632.9	4716.2	4800.7	4886.4	4973.4	5061.7	55
71.1	52.1	34.3	17.6	02.1	87.8	74.9	63.2	56
72.5	53.5	35.6	19.0	03.5	89.3	76.3	64.7	57
73.8	54.9	37.0	20.4	04.9	90.7	77.8	66.2	58
75.2	56.2	38.4	21.8	06.3	92.1	79.2	67.7	59
4476.5	4557.6	4639.8	4723.2	4807.7	4893.6	4980.7	5069.2	60
75°	76°	77°	78°	79°	80°	81°	82°	

TABLE III.—TANGENT DISTANCES FOR A 1° CURVE.

M.	83°	84°	85°	86°	87°	88°	89°	90°	M.
0	5069.2	5159.0	5250.3	5343.0	5437.2	5533.1	5630.5	5729.7	0
1	70.7	60.5	51.8	44.5	38.8	34.7	32.2	31.3	1
2	72.1	62.0	53.3	46.1	40.4	36.3	33.8	33.0	2
3	73.6	63.5	54.9	47.7	42.0	37.9	35.4	34.7	3
4	75.1	65.0	56.4	49.2	43.6	39.5	37.1	36.3	4
5	5076.6	5166.6	5257.9	5350.8	5445.2	5541.1	5638.7	5738.0	5
6	78.1	68.1	59.5	52.3	46.7	42.7	40.3	39.7	6
7	79.6	69.6	61.0	53.9	48.3	44.3	42.0	41.3	7
8	81.1	71.1	62.5	55.5	49.9	46.0	43.6	43.0	8
9	82.6	72.6	64.1	57.0	51.5	47.6	45.3	44.7	9
10	5084.0	5174.1	5265.6	5358.6	5453.1	5549.2	5646.9	5746.3	10
11	85.5	75.6	67.1	60.1	54.7	50.8	48.6	48.0	11
12	87.0	77.1	68.7	61.7	56.3	52.4	50.2	49.7	12
13	88.5	78.7	70.2	63.3	57.9	54.0	51.8	51.4	13
14	90.0	80.2	71.8	64.8	59.5	55.7	53.5	53.0	14
15	5091.5	5181.7	5273.3	5366.4	5461.0	5557.3	5655.1	5754.7	15
16	93.0	83.2	74.8	68.0	62.6	58.9	56.8	56.4	16
17	94.5	84.7	76.4	69.5	64.2	60.5	58.4	58.1	17
18	96.0	86.2	77.9	71.1	65.8	62.1	60.1	59.7	18
19	97.5	87.7	79.5	72.7	67.4	63.7	61.7	61.4	19
20	5099.0	5189.3	5281.0	5374.2	5469.0	5565.4	5663.4	5763.1	20
21	5100.4	90.8	82.5	75.8	70.6	67.0	65.0	64.8	21
22	01.9	92.3	84.1	77.4	72.2	68.6	66.7	66.4	22
23	03.4	93.8	85.6	78.9	73.8	70.2	68.3	68.1	23
24	04.9	95.3	87.2	80.5	75.4	71.8	70.0	69.8	24
25	5106.4	5196.8	5288.7	5382.1	5477.0	5573.5	5671.6	5771.5	25
26	07.9	98.4	90.3	83.6	78.6	75.1	73.3	73.2	26
27	09.4	99.9	91.8	85.2	80.2	76.7	74.9	74.8	27
28	10.9	5201.4	93.3	86.8	81.8	78.3	76.6	76.5	28
29	12.4	02.9	94.9	88.3	83.4	80.0	78.2	78.2	29
30	5113.9	5204.4	5296.4	5389.9	5484.9	5581.6	5679.9	5779.9	30
31	15.4	06.0	98.0	91.5	86.5	83.2	81.5	81.6	31
32	16.9	07.5	99.5	93.1	88.1	84.8	83.2	83.2	32
33	18.4	09.0	5301.1	94.6	89.7	86.5	84.8	84.9	33
34	19.9	10.5	02.6	96.2	91.3	88.1	86.5	86.6	34
35	5121.4	5212.1	5304.2	5397.8	5492.9	5589.7	5688.1	5788.3	35
36	22.9	13.6	05.7	99.3	94.5	91.3	89.8	90.0	36
37	24.4	15.1	07.3	5400.9	96.1	93.0	91.4	91.7	37
38	25.9	16.6	08.8	02.5	97.7	94.6	93.1	93.3	38
39	27.4	18.2	10.4	04.1	99.3	96.2	94.8	95.0	39
40	5128.9	5219.7	5311.9	5405.6	5500.9	5597.8	5696.4	5796.7	40
41	30.4	21.2	13.5	07.2	02.5	99.5	98.1	98.4	41
42	31.9	22.7	15.0	08.8	04.1	5601.1	99.7	5800.1	42
43	33.4	24.3	16.6	10.4	05.7	02.7	5701.4	01.8	43
44	34.9	25.8	18.1	12.0	07.3	04.4	03.0	03.5	44
45	5136.4	5227.3	5319.7	5413.5	5509.0	5606.0	5704.7	5805.1	45
46	37.9	28.8	21.2	15.1	10.6	07.6	06.4	06.8	46
47	39.4	30.4	22.8	16.7	12.2	09.3	08.0	08.5	47
48	40.9	31.9	24.3	18.3	13.8	10.9	09.7	10.2	48
49	42.4	33.4	25.9	19.8	15.4	12.5	11.3	11.9	49
50	5143.9	5234.9	5327.4	5421.4	5517.0	5614.2	5713.0	5813.6	50
51	45.4	36.5	29.0	23.0	18.6	15.8	14.7	15.3	51
52	46.9	38.0	30.5	24.6	20.2	17.4	16.3	17.0	52
53	48.4	39.5	32.1	26.2	21.8	19.1	18.0	18.7	53
54	50.0	41.1	33.6	27.7	23.4	20.7	19.7	20.4	54
55	5151.5	5242.6	5335.2	5429.3	5525.0	5622.3	5721.3	5822.1	55
56	53.0	44.1	36.8	30.9	26.6	24.0	23.0	23.8	56
57	54.5	45.7	38.3	32.5	28.2	25.6	24.7	25.4	57
58	56.0	47.2	39.9	34.1	29.8	27.2	26.3	27.1	58
59	57.5	48.7	41.4	35.7	31.4	28.9	28.0	28.8	59
60	5159.0	5250.3	5343.0	5437.2	5533.1	5630.5	5729.7	5830.5	60
	83°	84°	85°	86°	87°	88°	89°	90°	

°	92°	93°	94°	95°	96°	97°	98°	M.
5	5933.2	6037.8	6144.3	6252.8	6363.4	6476.2	6591.2	0
2	35.0	39.6	46.1	54.6	65.3	78.1	93.1	1
9	36.7	41.3	47.9	56.5	67.1	80.0	95.1	2
6	38.4	43.1	49.7	58.3	69.0	81.9	97.0	3
3	40.1	44.8	51.5	60.1	70.9	83.8	99.0	4
0	5941.9	6046.6	6153.3	6262.0	6372.7	6485.7	6600.9	5
7	43.6	48.4	55.1	63.8	74.6	87.6	02.8	6
4	45.3	50.1	56.9	65.6	76.5	89.5	04.8	7
1	47.1	51.9	58.6	67.4	78.3	91.4	06.7	8
8	48.8	53.6	60.4	69.3	80.2	93.3	08.7	9
5	5950.5	6055.4	6162.2	6271.1	6382.1	6495.2	6610.6	10
2	52.3	57.2	64.0	72.9	83.9	97.1	12.5	11
9	54.0	58.9	65.8	74.8	85.8	99.0	14.5	12
6	55.7	60.7	67.6	76.6	87.7	6500.9	16.4	13
3	57.5	62.5	69.4	78.4	89.5	02.8	18.4	14
0	5959.2	6064.2	6171.2	6280.3	6391.4	6504.7	6620.3	15
7	60.9	66.0	73.0	82.1	93.3	06.6	22.3	16
4	62.7	67.8	74.8	83.9	95.2	08.5	24.2	17
1	64.4	69.5	76.6	85.8	97.0	10.5	26.2	18
9	66.1	71.3	78.4	87.6	98.9	12.4	28.1	19
6	5967.9	6073.1	6180.2	6289.4	6400.8	6514.3	6630.1	20
3	69.6	74.8	82.0	91.3	02.6	16.2	32.0	21
0	71.3	76.6	83.9	93.1	04.5	18.1	34.0	22
7	73.1	78.4	85.7	95.0	06.4	20.0	35.9	23
4	74.8	80.2	87.5	96.8	08.3	21.9	37.9	24
1	5976.6	6081.9	6189.3	6298.6	6410.1	6523.8	6639.8	25
8	78.3	83.7	91.1	6300.5	12.0	25.8	41.8	26
5	80.0	85.5	92.9	02.3	13.9	27.7	43.7	27
2	81.8	87.2	94.7	04.2	15.8	29.6	45.7	28
9	83.5	89.0	96.5	06.0	17.7	31.5	47.6	29
7	5985.3	6090.8	6198.3	6307.9	6419.5	6533.4	6649.6	30
4	87.0	92.6	6200.1	09.7	21.4	35.3	51.5	31
1	88.8	94.3	01.9	11.5	23.3	37.2	53.5	32
8	90.5	96.1	03.7	13.4	25.2	39.2	55.5	33
5	92.2	97.9	05.5	15.2	27.1	41.1	57.4	34
2	5994.0	6099.7	6207.4	6317.1	6428.9	6543.0	6659.4	35
9	95.7	6101.5	09.2	18.9	30.8	44.9	61.3	36
6	97.5	03.2	11.0	20.8	32.7	46.8	63.3	37
4	99.2	05.0	12.8	22.6	34.6	48.8	65.3	38
1	6001.0	06.8	14.6	24.5	36.5	50.7	67.2	39
8	6002.7	6108.6	6216.4	6326.3	6438.4	6552.6	6669.2	40
5	04.5	10.4	18.2	28.2	40.2	54.5	71.1	41
2	06.2	12.1	20.0	30.0	42.1	56.5	73.1	42
9	08.0	13.9	21.9	31.9	44.0	58.4	75.1	43
7	09.7	15.7	23.7	33.7	45.9	60.3	77.0	44
4	6011.5	6117.5	6225.5	6335.6	6447.8	6562.2	6679.0	45
1	13.2	19.3	27.3	37.4	49.7	64.2	81.0	46
8	15.0	21.1	29.1	39.3	51.6	66.1	82.9	47
5	16.7	22.8	30.9	41.1	53.5	68.0	84.9	48
3	18.5	24.6	32.8	43.0	55.4	70.0	86.9	49
0	6020.2	6126.4	6234.6	6344.8	6457.2	6571.9	6688.8	50
7	22.0	28.2	36.4	46.7	59.1	73.8	90.8	51
4	23.7	30.0	38.2	48.6	61.0	75.7	92.8	52
2	25.5	31.8	40.0	50.4	62.9	77.7	94.7	53
9	27.2	33.6	41.9	52.3	64.8	79.6	96.7	54
6	6029.0	6135.3	6243.7	6354.1	6466.7	6581.5	6698.7	55
3	30.8	37.1	45.5	56.0	68.6	83.5	6700.7	56
0	32.5	38.9	47.3	57.8	70.5	85.4	02.6	57
8	34.3	40.7	49.2	59.7	72.4	87.3	04.6	58
5	36.0	42.5	51.0	61.6	74.3	89.3	06.6	59
2	6037.8	6144.3	6252.8	6363.4	6476.2	6591.2	6708.6	60
°	92°	93°	94°	95°	96°	97°	98°	

TABLE IV.—CORRECTIONS FOR TANGENT DISTANCES.

Int. Ang. I	DEGREE OF CURVE.												Int. Ang. I
	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	
1°	.00	.00	.00	.00	.00	.00	.01	.01	.01	.01	.01	.01	1°
2	.00	.00	.00	.01	.01	.01	.01	.01	.01	.01	.02	.02	2
3	.00	.01	.01	.01	.01	.01	.02	.02	.02	.02	.02	.02	3
4	.00	.01	.01	.01	.01	.02	.02	.02	.03	.03	.03	.03	4
5	.00	.01	.01	.02	.02	.02	.03	.03	.03	.03	.04	.04	5
6	.01	.01	.01	.02	.02	.03	.03	.03	.04	.04	.05	.05	6
7	.01	.01	.02	.02	.03	.03	.04	.04	.04	.05	.05	.06	7
8	.01	.01	.02	.02	.03	.03	.04	.05	.05	.06	.06	.07	8
9	.01	.02	.02	.03	.03	.04	.05	.05	.06	.06	.07	.07	9
10	.01	.02	.02	.03	.04	.04	.05	.06	.06	.07	.08	.08	10
11	.01	.02	.03	.03	.04	.05	.06	.06	.07	.08	.08	.09	11
12	.01	.02	.03	.04	.04	.05	.06	.07	.08	.08	.09	.10	12
13	.01	.02	.03	.04	.05	.06	.07	.07	.08	.09	.10	.11	13
14	.01	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	14
15	.01	.03	.04	.05	.06	.07	.08	.09	.09	.10	.11	.12	15
16	.02	.03	.04	.05	.06	.07	.08	.09	.10	.11	.12	.13	16
17	.02	.03	.04	.05	.06	.07	.09	.10	.11	.12	.13	.14	17
18	.02	.03	.04	.06	.07	.08	.09	.10	.11	.13	.14	.15	18
19	.02	.03	.05	.06	.07	.08	.10	.11	.12	.13	.15	.16	19
20	.02	.03	.05	.06	.07	.09	.10	.11	.13	.14	.15	.17	20
21	.02	.04	.05	.06	.08	.09	.11	.12	.13	.15	.16	.17	21
22	.02	.04	.05	.07	.08	.10	.11	.13	.14	.15	.17	.18	22
23	.02	.04	.06	.07	.09	.10	.12	.13	.15	.16	.18	.19	23
24	.02	.04	.06	.07	.09	.11	.12	.14	.15	.17	.18	.20	24
25	.02	.04	.06	.08	.09	.11	.13	.14	.16	.18	.19	.21	25
26	.03	.04	.06	.08	.10	.12	.13	.15	.17	.18	.20	.22	26
27	.03	.05	.07	.08	.10	.12	.14	.16	.17	.19	.21	.23	27
28	.03	.05	.07	.09	.11	.12	.14	.16	.18	.20	.22	.23	28
29	.03	.05	.07	.09	.11	.13	.15	.17	.19	.21	.22	.24	29
30	.03	.05	.07	.09	.11	.13	.15	.17	.19	.21	.23	.25	30
31	.03	.05	.08	.10	.12	.14	.16	.18	.20	.22	.24	.26	31
32	.03	.06	.08	.10	.12	.14	.16	.19	.21	.23	.25	.27	32
33	.03	.06	.08	.10	.13	.15	.17	.19	.21	.24	.26	.28	33
34	.03	.06	.08	.11	.13	.15	.18	.20	.22	.24	.27	.29	34
35	.03	.06	.09	.11	.13	.16	.18	.20	.23	.25	.27	.30	35
36	.04	.06	.09	.11	.14	.16	.19	.21	.23	.26	.28	.31	36
37	.04	.06	.09	.12	.14	.17	.19	.22	.24	.27	.29	.31	37
38	.04	.07	.09	.12	.15	.17	.20	.22	.25	.27	.30	.32	38
39	.04	.07	.10	.12	.15	.18	.20	.23	.26	.28	.31	.33	39
40	.04	.07	.10	.13	.15	.18	.21	.24	.26	.29	.32	.34	40
41	.04	.07	.10	.13	.16	.19	.21	.24	.27	.30	.32	.35	41
42	.04	.07	.10	.13	.16	.19	.22	.25	.28	.30	.33	.36	42
43	.04	.08	.11	.14	.17	.20	.23	.25	.28	.31	.34	.37	43
44	.04	.08	.11	.14	.17	.20	.23	.26	.29	.32	.35	.38	44
45	.05	.08	.11	.14	.18	.21	.24	.27	.30	.33	.36	.39	45
46	.05	.08	.12	.15	.18	.21	.24	.27	.31	.34	.37	.40	46
47	.05	.08	.12	.15	.18	.22	.25	.28	.31	.35	.38	.41	47
48	.05	.09	.12	.16	.19	.22	.26	.29	.32	.35	.39	.42	48
49	.05	.09	.12	.16	.19	.23	.26	.29	.33	.36	.40	.43	49
50	.05	.09	.13	.16	.20	.23	.27	.30	.34	.37	.40	.44	50
51	.05	.09	.13	.17	.20	.24	.27	.31	.34	.38	.41	.45	51
52	.05	.09	.13	.17	.21	.24	.28	.32	.35	.39	.42	.46	52
53	.05	.10	.14	.17	.21	.25	.29	.32	.36	.40	.43	.47	53
54	.06	.10	.14	.18	.22	.25	.29	.33	.37	.40	.44	.48	54
55	.06	.10	.14	.18	.22	.26	.30	.34	.38	.41	.45	.49	55
56	.06	.10	.15	.19	.23	.27	.30	.34	.38	.42	.46	.50	56
57	.06	.11	.15	.19	.23	.27	.31	.35	.39	.43	.47	.51	57
58	.06	.11	.15	.19	.24	.28	.32	.36	.40	.44	.48	.52	58
59	.06	.11	.15	.20	.24	.28	.32	.37	.41	.45	.49	.53	59
60	.06	.11	.16	.20	.24	.29	.33	.37	.42	.46	.50	.54	60
	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	

DEGREE OF CURVE.										Int. Ang.
4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	I
.16	.21	.25	.29	.34	.38	.42	.47	.51	.55	61°
.16	.21	.25	.30	.34	.39	.43	.48	.52	.57	62
.17	.21	.26	.31	.35	.40	.44	.49	.53	.58	63
.17	.22	.27	.31	.36	.40	.45	.50	.54	.59	64
.17	.22	.27	.32	.37	.41	.46	.51	.55	.60	65
.18	.23	.28	.32	.37	.42	.47	.52	.56	.61	66
.18	.23	.28	.33	.38	.43	.48	.53	.57	.62	67
.18	.24	.29	.34	.39	.44	.49	.54	.59	.63	68
.19	.24	.29	.34	.39	.44	.50	.55	.60	.65	69
.19	.24	.30	.35	.40	.45	.50	.56	.61	.66	70
.19	.25	.30	.36	.41	.46	.51	.57	.62	.67	71
.20	.25	.31	.36	.42	.47	.52	.58	.63	.68	72
.20	.26	.31	.37	.42	.48	.53	.59	.64	.70	73
.21	.26	.32	.38	.43	.49	.54	.60	.65	.71	74
.21	.27	.33	.38	.44	.50	.55	.61	.67	.72	75
.21	.27	.33	.39	.45	.51	.56	.62	.68	.74	76
.22	.28	.34	.40	.46	.51	.57	.63	.69	.75	77
.22	.28	.34	.40	.46	.52	.58	.64	.70	.76	78
.22	.29	.35	.41	.47	.53	.59	.65	.72	.78	79
.23	.29	.36	.42	.48	.54	.60	.67	.73	.79	80
.23	.30	.36	.43	.49	.55	.62	.68	.74	.80	81
.24	.30	.37	.43	.50	.56	.63	.69	.75	.82	82
.24	.31	.38	.44	.51	.57	.64	.70	.77	.83	83
.25	.31	.38	.45	.52	.58	.65	.72	.78	.85	84
.25	.32	.39	.46	.53	.59	.66	.73	.80	.86	85
.25	.33	.40	.47	.53	.60	.67	.74	.81	.88	86
.26	.33	.40	.47	.54	.61	.68	.75	.82	.89	87
.26	.34	.41	.48	.55	.62	.70	.77	.84	.91	88
.27	.34	.42	.49	.56	.64	.71	.78	.85	.92	89
.27	.35	.42	.50	.57	.65	.72	.79	.87	.94	90
.28	.36	.43	.51	.58	.66	.73	.81	.88	.96	91
.28	.36	.44	.52	.59	.67	.75	.82	.90	.97	92
.29	.37	.45	.53	.60	.68	.76	.84	.91	.99	93
.29	.37	.46	.53	.61	.69	.77	.85	.93	1.01	94
.30	.38	.46	.54	.63	.71	.79	.87	.95	1.03	95
.30	.39	.47	.55	.64	.72	.80	.88	.96	1.05	96
.31	.39	.48	.56	.65	.73	.81	.90	.98	1.06	97
.31	.40	.49	.57	.66	.74	.83	.91	1.00	1.08	98
.32	.41	.50	.58	.67	.76	.84	.93	1.02	1.10	99
.33	.42	.51	.59	.68	.77	.86	.95	1.03	1.12	100
.33	.42	.51	.61	.70	.78	.87	.96	1.05	1.14	101
.34	.43	.52	.62	.71	.80	.89	.98	1.07	1.16	102
.34	.44	.53	.63	.72	.81	.91	1.00	1.09	1.18	103
.35	.45	.54	.64	.73	.83	.92	1.02	1.11	1.20	104
.36	.46	.55	.65	.75	.84	.94	1.04	1.13	1.23	105
.36	.46	.56	.66	.76	.86	.96	1.05	1.15	1.25	106
.37	.47	.57	.67	.77	.87	.97	1.07	1.17	1.27	107
.38	.48	.58	.69	.79	.89	.99	1.09	1.19	1.30	108
.38	.49	.59	.70	.80	.91	1.01	1.11	1.22	1.32	109
.39	.50	.61	.71	.82	.92	1.03	1.13	1.24	1.34	110
.40	.51	.62	.73	.83	.94	1.05	1.16	1.26	1.37	111
.40	.52	.63	.74	.85	.96	1.07	1.18	1.29	1.40	112
.41	.53	.64	.75	.87	.98	1.09	1.20	1.31	1.42	113
.42	.54	.65	.77	.88	1.00	1.11	1.22	1.34	1.45	114
.43	.55	.67	.78	.90	1.01	1.13	1.25	1.36	1.48	115
.44	.56	.68	.80	.92	1.04	1.15	1.27	1.39	1.51	116
.45	.57	.69	.81	.94	1.06	1.18	1.30	1.42	1.54	117
.45	.58	.71	.83	.95	1.08	1.20	1.32	1.44	1.57	118
.46	.59	.72	.85	.97	1.10	1.22	1.35	1.47	1.60	119
.47	.60	.73	.86	.99	1.12	1.25	1.38	1.50	1.63	120
4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	

TABLE V.—EXTERNAL DISTANCES FOR A 1° CURV

Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Ang I
1° 0′	.2	11° 0′	26.5	21° 0′	97.6	31° 0′	216.2	41° 0′	387.4	51°
10	.3	10	27.3	10	99.2	10	218.7	10	390.7	
20	.4	20	28.1	20	100.7	20	221.1	20	394.1	
30	.5	30	29.0	30	102.3	30	223.5	30	397.4	
40	.6	40	29.8	40	104.0	40	226.0	40	400.8	
50	.7	50	30.7	50	105.6	50	228.4	50	404.2	
2° 0	.9	12° 0	31.6	22° 0	107.2	32° 0	230.9	42° 0	407.6	52°
10	1.0	10	32.4	10	108.9	10	233.4	10	411.1	
20	1.2	20	33.3	20	110.6	20	235.9	20	414.5	
30	1.4	30	34.3	30	112.3	30	238.4	30	418.0	
40	1.6	40	35.2	40	113.9	40	241.0	40	421.5	
50	1.8	50	36.1	50	115.7	50	243.5	50	425.0	
3° 0	2.0	13° 0	37.1	23° 0	117.4	33° 0	246.1	43° 0	428.5	53°
10	2.2	10	38.0	10	119.1	10	248.7	10	432.0	
20	2.4	20	39.0	20	120.9	20	251.3	20	435.6	
30	2.7	30	40.0	30	122.6	30	253.9	30	439.2	
40	2.9	40	41.0	40	124.4	40	256.5	40	442.7	
50	3 2	50	42.0	50	126.2	50	259.1	50	446.4	
4° 0	3.5	14° 0	43.0	24° 0	128.0	34° 0	261.8	44° 0	450.0	54°
10	3.8	10	44.1	10	129.8	10	264.5	10	453.6	
20	4.1	20	45.1	20	131.7	20	267.2	20	457.3	
30	4.4	30	46.2	30	133.5	30	269.9	30	460.9	
40	4.8	40	47.3	40	135.4	40	272.6	40	464.6	
50	5.1	50	48.3	50	137.2	50	275.3	50	468.4	
5° 0	5.5	15° 0	49.4	25° 0	139.1	35° 0	278.1	45° 0	472.1	55°
10	5.8	10	50.6	10	141.0	10	280.8	10	475.8	
20	6.2	20	51.7	20	142.9	20	283.6	20	479.6	
30	6.6	30	52.8	30	144.9	30	286.4	30	483.4	
40	7.0	40	54.0	40	146.8	40	289.2	40	487.2	
50	7.4	50	55.1	50	148.7	50	292.0	50	491.0	
6° 0	7.9	16° 0	56.3	26° 0	150.7	36° 0	294.9	46° 0	494.8	56°
10	8.3	10	57.5	10	152.7	10	297.7	10	498.7	
20	8.8	20	58.7	20	154.7	20	300.6	20	502.5	
30	9.2	30	59.9	30	156.7	30	303.5	30	506.4	
40	9.7	40	61.1	40	158.7	40	306.4	40	510.3	
50	10.2	50	62.4	50	160.8	50	309.3	50	514.3	
7° 0	10.7	17° 0	63.6	27° 0	162.8	37° 0	312.2	47° 0	518.2	57°
10	11.2	10	64.9	10	164.9	10	315.2	10	522.2	
20	11.8	20	66.2	20	167.0	20	318.1	20	526.1	
30	12.3	30	67.5	30	169.0	30	321.1	30	530.1	
40	12.8	40	68.8	40	171.2	40	324.1	40	534.1	
50	13.4	50	70.1	50	173.3	50	327.1	50	538.2	
8° 0	14.0	18° 0	71.4	28° 0	175.4	38° 0	330.1	48° 0	542.2	58°
10	14.6	10	72.8	10	177.6	10	333.2	10	546.3	
20	15.2	20	74.1	20	179.7	20	336.2	20	550.4	
30	15.8	30	75.5	30	181.9	30	339.3	30	554.5	
40	16.4	40	76.9	40	184.1	40	342.4	40	558.6	
50	17.1	50	78.3	50	186.3	50	345.5	50	562.8	
9° 0	17.7	19° 0	79.7	29° 0	188.5	39° 0	348.6	49° 0	566.9	59°
10	18.4	10	81.1	10	190.7	10	351.8	10	571.1	
20	19.1	20	82.5	20	193.0	20	354.9	20	575.3	
30	19.7	30	84.0	30	195.2	30	358.1	30	579.5	
40	20.4	40	85.4	40	197.5	40	361.3	40	583.8	
50	21.2	50	86.9	50	199.8	50	364.5	50	588.0	
10° 0	21.9	20° 0	88.4	30° 0	202.1	40° 0	367.7	50° 0	592.3	60°
10	22.6	10	89.9	10	204.4	10	371.0	10	596.6	
20	23.4	20	91.4	20	206.8	20	374.2	20	600.9	
30	24.1	30	92.9	30	209.1	30	377.5	30	605.3	
40	24.9	40	94.5	40	211.5	40	380.8	40	609.6	
50	25.7	50	96.0	50	213.9	50	384.1	50	614.0	

TABLE V.—EXTERNAL DISTANCES FOR A 1° CURVE.

Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.	Angle I.	Ext. Dis.
61° 0′	920.1	71° 0′	1308.2	81° 0′	1805.3	91° 0′	2444.9	101° 0′	3278.1
10	925.8	10	1315.5	10	1814.7	10	2457.1	10	3294.1
20	931.6	20	1322.9	20	1824.1	20	2469.3	20	3310.1
30	937.3	30	1330.3	30	1833.6	30	2481.5	30	3326.1
40	943.1	40	1337.7	40	1843.1	40	2493.8	40	3342.3
50	948.9	50	1345.1	50	1852.6	50	2506.1	50	3358.5
62° 0	954.8	72° 0	1352.6	82° 0	1862.2	92° 0	2518.5	102° 0	3374.9
10	960.6	10	1360.1	10	1871.8	10	2531.0	10	3391.2
20	966.5	20	1367.6	20	1881.5	20	2543.5	20	3407.7
30	972.4	30	1375.2	30	1891.2	30	2556.0	30	3424.3
40	978.3	40	1382.8	40	1900.9	40	2568.6	40	3440.9
50	984.3	50	1390.4	50	1910.7	50	2581.3	50	3457.6
63° 0	990.2	73° 0	1398.0	83° 0	1920.5	93° 0	2594.0	103° 0	3474.4
10	996.2	10	1405.7	10	1930.4	10	2606.8	10	3491.3
20	1002.3	20	1413.5	20	1940.3	20	2619.7	20	3508.2
30	1008.3	30	1421.2	30	1950.3	30	2632.6	30	3525.2
40	1014.4	40	1429.0	40	1960.2	40	2645.5	40	3542.4
50	1020.5	50	1436.8	50	1970.3	50	2658.5	50	3559.6
64° 0	1026.6	74° 0	1444.6	84° 0	1980.4	94° 0	2671.6	104° 0	3576.8
10	1032.8	10	1452.5	10	1990.5	10	2684.7	10	3594.2
20	1039.0	20	1460.4	20	2000.6	20	2697.9	20	3611.7
30	1045.2	30	1468.4	30	2010.8	30	2711.2	30	3629.2
40	1051.4	40	1476.4	40	2021.1	40	2724.5	40	3646.8
50	1057.7	50	1484.4	50	2031.4	50	2737.9	50	3664.5
65° 0	1063.9	75° 0	1492.4	85° 0	2041.7	95° 0	2751.3	105° 0	3682.3
10	1070.2	10	1500.5	10	2052.1	10	2764.8	10	3700.2
20	1076.6	20	1508.6	20	2062.5	20	2778.3	20	3718.2
30	1082.9	30	1516.7	30	2073.0	30	2792.0	30	3736.2
40	1089.3	40	1524.9	40	2083.5	40	2805.6	40	3754.4
50	1095.7	50	1533.1	50	2094.1	50	2819.4	50	3772.6
66° 0	1102.2	76° 0	1541.4	86° 0	2104.7	96° 0	2833.2	106° 0	3791.0
10	1108.6	10	1549.7	10	2115.3	10	2847.0	10	3809.4
20	1115.1	20	1558.0	20	2126.0	20	2861.0	20	3827.9
30	1121.7	30	1566.3	30	2136.7	30	2875.0	30	3846.5
40	1128.2	40	1574.7	40	2147.5	40	2889.0	40	3865.2
50	1134.8	50	1583.1	50	2158.4	50	2903.1	50	3884.0
67° 0	1141.4	77° 0	1591.6	87° 0	2169.2	97° 0	2917.3	107° 0	3902.9
10	1148.0	10	1600.1	10	2180.2	10	2931.6	10	3921.9
20	1154.7	20	1608.6	20	2191.1	20	2945.9	20	3940.9
30	1161.3	30	1617.1	30	2202.2	30	2960.3	30	3960.1
40	1168.1	40	1625.7	40	2213.2	40	2974.7	40	3979.4
50	1174.8	50	1634.4	50	2224.3	50	2989.2	50	3998.7
68° 0	1181.6	78° 0	1643.0	88° 0	2235.5	98° 0	3003.8	108° 0	4018.0
10	1188.4	10	1651.7	10	2246.7	10	3018.4	10	4037.8
20	1195.2	20	1660.5	20	2258.0	20	3033.1	20	4057.4
30	1202.0	30	1669.2	30	2269.3	30	3047.9	30	4077.2
40	1208.9	40	1678.1	40	2280.6	40	3062.8	40	4097.1
50	1215.8	50	1686.9	50	2292.0	50	3077.7	50	4117.0
69° 0	1222.7	79° 0	1695.8	89° 0	2303.5	99° 0	3092.7	109° 0	4137.1
10	1229.7	10	1704.7	10	2315.0	10	3107.7	10	4157.3
20	1236.7	20	1713.7	20	2326.6	20	3122.9	20	4177.5
30	1243.7	30	1722.7	30	2338.2	30	3138.1	30	4197.9
40	1250.8	40	1731.7	40	2349.8	40	3153.3	40	4218.4
50	1257.8	50	1740.8	50	2361.5	50	3168.7	50	4239.0
70° 0	1265.0	80° 0	1749.9	90° 0	2373.3	100° 0	3184.1	110° 0	4259.7
10	1272.1	10	1759.0	10	2385.1	10	3199.6	10	4280.5
20	1279.3	20	1768.2	20	2397.0	20	3215.1	20	4301.4
30	1286.5	30	1777.4	30	2408.9	30	3230.8	30	4322.4
40	1293.7	40	1786.7	40	2420.9	40	3246.5	40	4343.6
50	1300.9	50	1796.0	50	2432.9	50	3262.3	50	4364.8

TABLE VI.—SPIRAL FOR 1°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	0.3°	30.00	0.03	60.00	0.10	60.00
80	0.4	40.00	0.05	80.00	0.19	80.00
100	0.5	50.00	0.07	100.00	0.29	100.00
120	0.6	60.00	0.10	120.00	0.42	120.00
140	0.7	70.00	0.14	140.00	0.57	140.00
160	0.8	80.00	0.19	160.00	0.74	160.00
180	0.9	90.00	0.24	180.00	0.94	180.00
200	1.0	100.00	0.29	199.99	1.16	200.00
220	1.1	110.00	0.35	219.99	1.41	220.00
240	1.2	120.00	0.42	239.99	1.68	240.00
260	1.3	130.00	0.49	259.99	1.97	259.99
280	1.4	140.00	0.57	279.98	2.28	279.99
300	1.5	149.99	0.65	299.98	2.62	299.99
320	1.6	159.99	0.74	319.98	2.98	319.99
340	1.7	169.99	0.84	339.97	3.36	339.99
360	1.8	179.99	0.94	359.97	3.77	359.98
380	1.9	189.99	1.05	379.96	4.20	379.98
400	2.0	199.99	1.16	399.95	4.65	399.98
420	2.1	209.99	1.28	419.94	5.13	419.98
440	2.2	219.99	1.41	439.94	5.63	439.97
460	2.3	229.99	1.54	459.93	6.15	459.97
480	2.4	239.98	1.68	479.92	6.70	479.96
500	2.5	249.98	1.82	499.91	7.27	499.96
520	2.6	259.98	1.97	519.89	7.86	519.95
540	2.7	269.98	2.12	539.88	8.48	539.95
560	2.8	279.98	2.28	559.87	9.12	559.94
580	2.9	289.97	2.45	579.85	9.78	579.94
600	3.0°	299.97	2.62	599.84	10.47	599.93

SPIRAL FOR 1°30′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	0.45°	30.00	0.04	60.00	0.16	60.00
80	0.60	40.00	0.07	80.00	0.28	80.00
100	0.75	50.00	0.11	100.00	0.44	100.00
120	0.90	60.00	0.16	120.00	0.63	120.00
140	1.05	70.00	0.21	140.00	0.86	140.00
160	1.20	80.00	0.28	159.99	1.12	160.00
180	1.35	90.00	0.35	179.99	1.41	180.00
200	1.50	99.99	0.44	199.99	1.75	199.99
220	1.65	109.99	0.53	219.98	2.11	219.99
240	1.80	119.99	0.63	239.98	2.51	239.99
260	1.95	129.99	0.74	259.97	2.95	259.99
280	2.10	139.99	0.86	279.96	3.42	279.98
300	2.25	149.99	0.98	299.95	3.93	299.98
320	2.40	159.99	1.12	319.94	4.47	319.98
340	2.55	169.98	1.26	339.93	5.04	339.97
360	2.70	179.98	1.41	359.92	5.65	359.97
380	2.85	189.98	1.57	379.91	6.30	379.96
400	3.00	199.98	1.75	399.89	6.98	399.95
420	3.15	209.97	1.92	419.87	7.70	419.94
440	3.30	219.97	2.11	439.85	8.45	439.94
460	3.45	229.97	2.31	459.83	9.23	459.93
480	3.60	239.96	2.51	479.81	10.05	479.92
500	3.75	249.96	2.73	499.79	10.90	499.91
520	3.90	259.95	2.95	519.76	11.79	519.89
540	4.05	269.95	3.18	539.73	12.72	539.88
560	4.20	279.94	3.42	559.70	13.68	559.87
580	4.35	289.94	3.67	579.67	14.67	579.85
600	4.50°	299.93	3.93	599.63	15.70	599.84

TABLE VI. — SPIRAL FOR 2°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
0.6°	30.00	0.05	60.00	0.21	60.00	0°36′
0.8	40.00	0.09	80.00	0.37	80.00	0 48
1.0	50.00	0.15	100.00	0.58	100.00	1 00
1.2	60.00	0.21	119.99	0.84	120.00	1 12
1.4	70.00	0.29	139.99	1.14	140.00	1 24
1.6	79.99	0.37	159.99	1.49	159.99	1 36
1.8	89.99	0.47	179.98	1.88	179.99	1 48
2.0	99.99	0.58	199.98	2.33	199.99	2 00
2.2	109.99	0.70	219.97	2.82	219.99	2 12
2.4	119.99	0.84	239.96	3.35	239.98	2 24
2.6	129.98	0.98	259.95	3.93	259.98	2 36
2.8	139.98	1.14	279.93	4.56	279.97	2 48
3.0	149.98	1.31	299.92	5.24	299.96	3 00
3.2	159.98	1.49	319.90	5.96	319.96	3 12
3.4	169.97	1.68	339.88	6.72	339.95	3 24
3.6	179.97	1.88	359.86	7.54	359.94	3 36
3.8	189.96	2.10	379.83	8.40	379.93	3 48
4.0	199.96	2.33	399.81	9.31	399.91	4 00
4.2	209.95	2.56	419.78	10.26	419.90	4 12
4.4	219.95	2.81	439.74	11.26	439.89	4 24
4.6	229.94	3.08	459.71	12.31	459.87	4 36
4.8	239.93	3.35	479.66	13.40	479.85	4 48
5.0	249.93	3.63	499.62	14.54	499.83	5 00
5.2	259.92	3.93	519.57	15.72	519.81	5 12
5.4	269.91	4.24	539.52	16.95	539.79	5 24
5.6	279.90	4.56	559.47	18.23	559.77	5 36
5.8	289.89	4.89	579.41	19.56	579.74	5 48
6.0°	299.88	5.23	599.35	20.93	599.71	6°00′

SPIRAL FOR 2°30′ CURVE

s_c	q	p	y_c	x_c	C	s_c
0.75°	30.00	0.07	60.00	0.26	60.00	0°45′
1.00	40.00	0.12	80.00	0.47	80.00	1 00
1.25	50.00	0.18	100.00	0.73	100.00	1 15
1.50	59.99	0.26	119.99	1.05	120.00	1 30
1.75	69.99	0.36	139.99	1.43	139.99	1 45
2.00	79.99	0.47	159.98	1.86	159.99	2 00
2.25	89.99	0.59	179.97	2.36	179.99	2 15
2.50	99.99	0.73	199.96	2.91	199.98	2 30
2.75	109.98	0.88	219.95	3.52	219.98	2 45
3.00	119.98	1.05	239.93	4.19	239.97	3 00
3.25	129.98	1.23	259.92	4.91	259.96	3 15
3.50	139.97	1.42	279.90	5.70	279.95	3 30
3.75	149.97	1.64	299.87	6.54	299.94	3 45
4.00	159.96	1.86	319.84	7.44	319.93	4 00
4.25	169.96	2.10	339.81	8.40	339.92	4 15
4.50	179.95	2.36	359.78	9.42	359.90	4 30
4.75	189.94	2.62	379.74	10.50	379.89	4 45
5.00	199.94	2.91	399.70	11.63	399.87	5 00
5.25	209.93	3.21	419.65	12.82	419.85	5 15
5.50	219.92	3.52	439.60	14.07	439.82	5 30
5.75	229.91	3.84	459.54	15.38	459.80	5 45
6.00	239.90	4.19	479.48	16.74	479.77	6 00
6.25	249.88	4.54	499.41	18.17	499.74	6 15
6.50	259.87	4.91	519.33	19.65	519.71	6 30
6.75	269.86	5.30	539.25	21.18	539.67	6 45
7.00	279.84	5.70	559.17	22.78	559.63	7 00
7.25	289.83	6.11	579.08	24.44	579.59	7 15
7.50°	299.81	6.54	598.98	26.15	599.55	7°30′

TABLE VI. — SPIRAL FOR 3°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	0.9°	30.00	0.08	60.00	0.31	60.00
80	1.2	39.99	0.14	80.00	0.56	80.00
100	1.5	49.99	0.22	99.99	0.87	100.00
120	1.8	59.99	0.31	119.99	1.26	119.99
140	2.1	69.99	0.43	139.98	1.71	139.99
160	2.4	79.99	0.56	159.97	2.23	159.99
180	2.7	89.98	0.71	179.96	2.83	179.98
200	3.0	99.98	0.87	199.95	3.49	199.98
220	3.3	109.98	1.06	219.93	4.22	219.97
240	3.6	119.97	1.26	239.91	5.03	239.96
260	3.9	129.97	1.47	259.88	5.90	259.95
280	4.2	139.96	1.71	279.85	6.84	279.93
300	4.5	149.95	1.96	299.82	7.85	299.92
320	4.8	159.95	2.23	319.78	8.93	319.90
340	5.1	169.94	2.52	339.73	10.08	339.88
360	5.4	179.93	2.83	359.68	11.30	359.86
380	5.7	189.92	3.15	379.63	12.59	379.84
400	6.0	199.91	3.49	399.56	13.95	399.81
420	6.3	209.89	3.85	419.50	15.38	419.78
440	6.6	219.88	4.22	439.42	16.88	439.74
460	6.9	229.87	4.61	459.34	18.45	459.71
480	7.2	239.85	5.02	479.25	20.08	479.67
500	7.5°	249.83	5.45	499.15	21.79	499.62

SPIRAL FOR 3°30′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	1.05°	30.00	0.09	60.00	0.37	60.00
80	1.40	39.99	0.16	80.00	0.65	80.00
100	1.75	49.99	0.25	99.99	1.02	100.00
120	2.10	59.99	0.37	119.98	1.47	119.99
140	2.45	69.99	0.50	139.97	2.00	139.99
160	2.80	79.98	0.65	159.96	2.61	159.98
180	3.15	89.98	0.82	179.95	3.30	179.98
200	3.50	99.97	1.02	199.93	4.07	199.97
220	3.85	109.97	1.23	219.90	4.93	219.96
240	4.20	119.96	1.47	239.87	5.86	239.94
260	4.55	129.95	1.72	259.84	6.88	259.93
280	4.90	139.95	1.99	279.80	7.98	279.91
300	5.25	149.94	2.29	299.75	9.16	299.89
320	5.60	159.93	2.60	319.70	10.42	319.87
340	5.95	169.92	2.94	339.64	11.76	339.84
360	6.30	179.90	3.30	359.57	13.18	359.81
380	6.65	189.89	3.67	379.49	14.69	379.78
400	7.00	199.87	4.07	399.41	16.27	399.74
420	7.35	209.86	4.49	419.31	17.94	419.70
440	7.70	219.84	4.92	439.21	19.69	439.65
460	8.05	229.82	5.38	459.10	21.51	459.60
480	8.40	239.80	5.86	478.98	23.42	479.55
500	8.75°	249.77	6.36	498.84	25.41	499.49

TABLE VI.—SPIRAL FOR 4°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
1.2°	29.99	0.10	60.00	0.42	60.00	1°12′
1.6	39.99	0.19	79.99	0.74	80.00	1 36
2.0	49.99	0.29	99.99	1.16	99.99	2 00
2.4	59.98	0.42	119.98	1.68	119.99	2 24
2.8	69.98	0.57	139.97	2.28	139.99	2 48
3.2	79.98	0.74	159.95	2.98	159.98	3 12
3.6	89.97	0.94	179.93	3.77	179.97	3 36
4.0	99.96	1.16	199.90	4.65	199.96	4 00
4.4	109.96	1.41	219.87	5.63	219.94	4 24
4.8	119.95	1.67	239.83	6.70	239.93	4 48
5.2	129.94	1.96	259.79	7.86	259.91	5 12
5.6	139.93	2.28	279.73	9.12	279.88	5 36
6.0	149.92	2.62	299.67	10.46	299.86	6 00
6.4	159.90	2.98	319.60	11.90	319.82	6 24
6.8	169.89	3.36	339.52	13.44	339.79	6 48
7.2	179.87	3.77	359.44	15.06	359.75	7 12
7.6	189.85	4.20	379.34	16.78	379.71	7 36
8.0	199.83	4.65	399.23	18.59	399.66	8 00
8.4	209.81	5.12	419.10	20.49	419.60	8 24
8.8	219.79	5.62	438.97	22.49	439.54	8 48
9.2	229.76	6.15	458.82	24.58	459.48	9 12
9.6	239.73	6.69	478.66	26.76	479.41	9 36
10.0°	249.70	7.26	498.49	29.03	499.33	10°00′

SPIRAL FOR 4°30′ CURVE

s_c	q	p	y_c	x_c	C	s_c
1.35°	29.99	0.12	60.00	0.47	60.00	1°21′
1.80	39.99	0.21	79.99	0.84	80.00	1 48
2.25	49.98	0.33	99.98	1.31	99.99	2 15
2.70	59.98	0.47	119.97	1.88	119.99	2 42
3.15	69.98	0.64	139.96	2.57	139.98	3 09
3.60	79.97	0.84	159.94	3.35	159.97	3 36
4.05	89.96	1.06	179.91	4.24	179.96	4 03
4.50	99.95	1.31	199.88	5.23	199.95	4 30
4.95	109.95	1.58	219.84	6.33	219.93	4 57
5.40	119.93	1.88	239.79	7.54	239.91	5 24
5.85	129.92	2.21	259.73	8.84	259.88	5 51
6.30	139.91	2.56	279.66	10.25	279.85	6 18
6.75	149.89	2.94	299.59	11.77	299.82	6 45
7.20	159.88	3.35	319.50	13.39	319.78	7 12
7.65	169.86	3.78	339.40	15.11	339.73	7 39
8.10	179.84	4.23	359.29	16.94	359.68	8 06
8.55	189.81	4.72	379.16	18.87	379.63	8 33
9.00	199.79	5.23	399.02	20.91	399.57	9 00
9.45	209.76	5.76	418.87	23.05	419.50	9 27
9.90	219.73	6.32	438.70	25.29	439.42	9 54
10.35	229.70	6.91	458.51	27.63	459.34	10 21
10.80	239.66	7.53	478.31	30.08	479.25	10 48
11.25°	249.63	8.17	498.09	32.64	499.15	11°15′

TABLE VI. — SPIRAL FOR 5°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	1.5°	29.99	0.13	60.00	0.52	60.00
80	2.0	39.99	0.23	79.99	0.93	80.00
100	2.5	49.98	0.36	99.98	1.45	99.99
120	3.0	59.98	0.52	119.97	2.09	119.99
140	3.5	69.97	0.71	139.95	2.85	139.98
160	4.0	79.96	0.93	159.92	3.72	159.97
180	4.5	89.95	1.18	179.89	4.71	179.95
200	5.0	99.94	1.45	199.85	5.81	199.93
220	5.5	109.93	1.76	219.80	7.03	219.91
240	6.0	119.92	2.09	239.74	8.37	239.88
260	6.5	129.90	2.45	259.67	9.82	259.85
280	7.0	139.89	2.85	279.58	11.39	279.82
300	7.5	149.87	3.27	299.49	13.07	299.77
320	8.0	159.85	3.72	319.38	14.87	319.73
340	8.5	169.83	4.20	339.26	16.79	339.67
360	9.0	179.80	4.70	359.12	18.82	359.61
380	9.5	189.77	5.24	378.96	20.96	379.54
400	10.0°	199.74	5.81	398.79	23.22	399.47

SPIRAL FOR 5°30′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	1.65°	29.99	0.14	60.00	0.58	60.00
80	2.20	39.98	0.26	79.99	1.02	79.99
100	2.75	49.98	0.40	99.98	1.60	99.99
120	3.30	59.97	0.58	119.96	2.30	119.98
140	3.85	69.96	0.78	139.94	3.13	139.97
160	4.40	79.95	1.02	159.91	4.09	159.96
180	4.95	89.94	1.29	179.87	5.18	179.94
200	5.50	99.93	1.60	199.82	6.40	199.92
220	6.05	109.92	1.93	219.76	7.74	219.89
240	6.60	119.90	2.30	239.68	9.21	239.86
260	7.15	129.89	2.70	259.60	10.80	259.82
280	7.70	139.87	3.13	279.50	12.53	279.78
300	8.25	149.84	3.59	299.38	14.38	299.73
320	8.80	159.82	4.09	319.25	16.36	319.67
340	9.35	169.79	4.61	339.10	18.46	339.60
360	9.90	179.76	5.17	358.93	20.69	359.53
380	10.45	189.72	5.76	378.74	23.05	379.45
400	11.00°	199.69	6.38	398.54	25.53	399.35

SPIRAL FOR 6°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	1.8°	29.99	0.16	59.99	0.63	60.00
80	2.4	39.98	0.28	79.99	1.12	79.99
100	3.0	49.97	0.44	99.97	1.74	99.99
120	3.6	59.96	0.63	119.95	2.51	119.98
140	4.2	69.96	0.85	139.93	3.42	139.97
160	4.8	79.95	1.12	159.89	4.47	159.95
180	5.4	89.93	1.41	179.84	5.65	179.93
200	6.0	99.92	1.74	199.78	6.98	199.90
220	6.6	109.90	2.11	219.71	8.44	219.87
240	7.2	119.88	2.51	239.62	10.04	239.83
260	7.8	129.86	2.94	259.52	11.78	259.79
280	8.4	139.84	3.41	279.40	13.66	279.74
300	9.0	149.81	3.92	299.26	15.68	299.68
320	9.6	159.78	4.46	319.11	17.84	319.61
340	10.2	169.75	5.03	338.93	20.13	339.53
360	10.8°	179.71	5.64	358.73	22.56	359.44

TABLE VI. — SPIRAL FOR 6°30′ CURVE

s_c	q	p	y_c	x_c	C	s_c
1.95°	29.98	0.17	59.99	0.68	60.00	1°57′
2.60	39.98	0.30	79.98	1.21	79.99	2 36
3.25	49.97	0.47	99.97	1.89	99.99	3 15
3.90	59.96	0.68	119.94	2.72	119.98	3 54
4.55	69.95	0.92	139.91	3.70	139.96	4 33
5.20	79.94	1.21	159.87	4.84	159.94	5 12
5.85	89.92	1.53	179.81	6.12	179.92	5 51
6.50	99.91	1.89	199.74	7.56	199.89	6 30
7.15	109.89	2.28	219.66	9.14	219.85	7 09
7.80	119.86	2.72	239.56	10.88	239.80	7 48
8.45	129.84	3.19	259.44	12.76	259.75	8 27
9.10	139.81	3.70	279.30	14.80	279.69	9 06
9.75	149.78	4.24	299.14	16.98	299.62	9 45
10.40	159.75	4.83	318.95	19.32	319.54	10 24
11.05	169.71	5.45	338.74	21.80	339.45	11 03
11.70°	179.66	6.11	358.51	24.43	359.34	11°42′

SPIRAL FOR 7°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
2.1°	29.98	0.18	59.99	0.73	60.00	2°06′
2.8	39.97	0.33	79.98	1.30	79.99	2 48
3.5	49.96	0.51	99.96	2.04	99.98	3 30
4.2	59.95	0.73	119.94	2.93	119.97	4 12
4.9	69.94	1.00	139.90	3.99	139.96	4 54
5.6	79.93	1.30	159.85	5.21	159.93	5 36
6.3	89.91	1.65	179.78	6.59	179.90	6 18
7.0	99.89	2.03	199.70	8.14	199.87	7 00
7.7	109.87	2.46	219.61	9.84	219.83	7 42
8.4	119.84	2.92	239.49	11.71	239.77	8 24
9.1	129.81	3.43	259.35	13.74	259.71	9 06
9.8	139.78	3.98	279.19	15.93	279.64	9 48
10.5	149.75	4.57	299.00	18.28	299.56	10 30
11.2	159.70	5.20	318.79	20.79	319.46	11 12
11.9	169.66	5.87	338.54	23.47	339.36	11 54
12.6°	179.61	6.57	358.27	26.30	359.24	12°36′

SPIRAL FOR 7°30′ CURVE

s_c	q	p	y_c	x_c	C	s_c
2.25°	29.98	0.20	59.99	0.79	60.00	2°15′
3.00	39.97	0.35	79.98	1.40	79.99	3 00
3.75	49.96	0.54	99.96	2.18	99.98	3 45
4.50	59.95	0.78	119.93	3.14	119.97	4 30
5.25	69.93	1.07	139.88	4.27	139.95	5 15
6.00	79.91	1.39	159.83	5.58	159.92	6 00
6.75	89.90	1.76	179.75	7.06	179.89	6 45
7.50	99.87	2.18	199.66	8.72	199.85	7 30
8.25	109.85	2.63	219.55	10.54	219.80	8 15
9.00	119.82	3.13	239.41	12.54	239.74	9 00
9.75	129.79	3.68	259.25	14.72	259.67	9 45
10.50	139.75	4.26	279.07	17.06	279.59	10 30
11.25	149.71	4.89	298.85	19.58	299.49	11 15
12.00	159.66	5.57	318.61	22.27	319.38	12 00
12.75	169.61	6.28	338.33	25.13	339.26	12 45
13.50°	179.55	7.04	358.02	28.16	359.12	13°30′

TABLE VI.—SPIRAL FOR 8°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	2.4°	29.97	0.21	59.99	0.84	60.00
80	3.2	39.96	0.37	79.98	1.49	79.99
100	4.0	49.95	0.58	99.95	2.33	99.98
120	4.8	59.94	0.84	119.92	3.35	119.96
140	5.6	69.92	1.14	139.87	4.56	139.94
160	6.4	79.90	1.49	159.80	5.95	159.91
180	7.2	89.88	1.88	179.72	7.53	179.88
200	8.0	99.86	2.32	199.61	9.30	199.83
220	8.8	109.83	2.81	219.48	11.24	219.77
240	9.6	119.79	3.34	239.33	13.38	239.70
260	10.4	129.76	3.92	259.15	15.69	259.62
280	11.2	139.71	4.54	278.94	18.20	279.53
300	12.0	149.67	5.22	298.69	20.88	299.42
320	12.8	159.61	5.93	318.42	23.75	319.30
340	13.6	169.55	6.70	338.10	26.79	339.16
360	14.4°	179.49	7.51	357.75	30.03	359.00

SPIRAL FOR 9°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	2.7°	29.97	0.23	59.99	0.94	59.99
80	3.6	39.95	0.42	79.97	1.68	79.99
100	4.5	49.94	0.65	99.94	2.62	99.97
120	5.4	59.92	0.94	119.89	3.77	119.95
140	6.3	69.90	1.28	139.83	5.13	139.93
160	7.2	79.88	1.67	159.75	6.69	159.89
180	8.1	89.85	2.11	179.64	8.47	179.84
200	9.0	99.82	2.61	199.51	10.45	199.78
220	9.9	109.78	3.16	219.35	12.64	219.71
240	10.8	119.74	3.75	239.15	15.04	239.63
260	11.7	129.69	4.40	258.92	17.65	259.52
280	12.6	139.64	5.11	278.66	20.46	279.41
300	13.5	149.58	5.86	298.35	23.47	299.27
320	14.4	159.51	6.67	318.00	26.69	319.11
340	15.3	169.44	7.53	337.60	30.11	338.94
360	16.2°	179.35	8.43	357.15	33.74	358.74

SPIRAL FOR 10°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	3.0°	29.96	0.26	59.98	1.05	59.99
80	4.0	39.94	0.46	79.96	1.86	79.98
100	5.0	49.92	0.72	99.92	2.91	99.97
120	6.0	59.90	1.04	119.87	4.19	119.94
140	7.0	69.88	1.42	139.79	5.70	139.91
160	8.0	79.85	1.85	159.69	7.44	159.86
180	9.0	89.81	2.35	179.56	9.41	179.81
200	10.0	99.78	2.90	199.40	11.61	199.73
220	11.0	109.73	3.50	219.20	14.04	219.64
240	12.0	119.68	4.17	238.96	16.70	239.54
260	13.0	129.62	4.89	258.67	19.59	259.41
280	14.0	139.56	5.67	278.34	22.71	279.27
300	15.0	149.48	6.51	297.96	26.05	299.10
320	16.0	159.40	7.40	317.53	29.62	318.91
340	17.0	169.31	8.35	337.04	33.42	338.69
360	18.0°	179.20	9.36	356.48	37.44	358.44

TABLE VI.—SPIRAL FOR 12°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
3.6°	29.94	0.31	59.98	1.26	59.99	3°36′
4.8	39.92	0.56	79.94	2.23	79.98	4 48
6.0	49.89	0.87	99.89	3.49	99.95	6 00
7.2	59.86	1.25	119.81	5.02	119.92	7 12
8.4	69.82	1.70	139.70	6.83	139.87	8 24
9.6	79.78	2.22	159.55	8.92	159.80	9 36
10.8	89.73	2.81	179.37	11.28	179.72	10 48
12.0	99.68	3.47	199.13	13.92	199.62	12 00
13.2	109.61	4.19	218.84	16.83	219.49	13 12
14.4	119.54	4.99	238.50	20.02	239.34	14 24
15.6	129.46	5.85	258.09	23.47	259.16	15 36
16.8	139.36	6.79	277.62	27.20	278.94	16 48
18.0	149.25	7.79	297.07	31.20	298.70	18 00
19.2	159.14	8.86	316.45	35.46	318.43	19 12
20.4	169.00	9.99	335.74	39.99	338.11	20 24
21.6°	178.86	11.20	354.95	44.79	357.76	21°36′

SPIRAL FOR 14°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
4.2°	29.92	0.36	59.97	1.47	59.99	4°12′
5.6	39.89	0.65	79.92	2.60	79.97	5 36
7.0	49.85	1.01	99.85	4.07	99.93	7 00
8.4	59.81	1.45	119.74	5.86	119.89	8 24
9.8	69.76	1.98	139.59	7.97	139.82	9 48
11.2	79.70	2.58	159.39	10.40	159.73	11 12
12.6	89.64	3.27	179.14	13.15	179.62	12 36
14.0	99.56	4.03	198.82	16.22	199.48	14 00
15.4	109.47	4.88	218.42	19.61	219.30	15 24
16.8	119.37	5.80	237.96	23.32	239.10	16 48
18.2	129.26	6.81	257.40	27.33	258.85	18 12
19.6	139.13	7.89	276.76	31.67	278.56	19 36
21.0	148.99	9.06	296.02	36.31	298.24	21 00
22.4	158.83	10.30	315.17	41.25	317.86	22 24
23.8	168.65	11.62	334.21	46.51	337.43	23 48
25.2°	178.45	13.02	353.14	52.06	356.95	25°12′

SPIRAL FOR 15°00′ CURVE

s_c	q	p	y_c	x_c	C	s_c
4.5°	29.91	0.39	59.96	1.57	59.98	4°30′
6.0	39.87	0.69	79.91	2.79	79.96	6 00
7.5	49.83	1.08	99.83	4.36	99.92	7 30
9.0	59.78	1.56	119.71	6.27	119.87	9°00′
10.5	69.73	2.12	139.53	8.53	139.79	10 30
12.0	79.66	2.76	159.30	11.14	159.69	12 00
13.5	89.58	3.50	179.01	14.08	179.56	13 30
15.0	99.50	4.32	198.64	17.37	199.40	15 00
16.5	109.40	5.22	218.19	21.00	219.20	16 30
18.0	119.28	6.21	237.66	24.96	238.96	18 00
19.5	129.15	7.28	257.02	29.26	258.68	19 30
21.0	139.00	8.44	276.28	33.89	278.35	21 00
22.5	148.84	9.69	295.43	38.84	297.97	22 30
24.0	158.65	11.01	314.46	44.13	317.54	24 00
25.5	168.45	12.42	333.36	49.74	337.05	25 30
27.0°	178.22	13.92	352.13	55.67	356.50	27°00′

TABLE VI. — SPIRAL FOR 16°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	4.8°	29.90	0.41	59.96	1.67	59.98
80	6.4	39.85	0.74	79.90	2.98	79.96
100	8.0	49.81	1.15	99.81	4.65	99.91
120	9.6	59.75	1.66	119.67	6.69	119.85
140	11.2	69.69	2.26	139.47	9.10	139.77
160	12.8	79.61	2.95	149.21	11.87	159.65
180	14.4	89.53	3.73	178.87	15.01	179.50
200	16.0	99.43	4.60	198.45	18.51	199.32
220	17.6	109.31	5.56	217.94	22.38	219.09
240	19.2	119.18	6.61	237.33	26.60	238.82
260	20.8	129.04	7.76	256.61	31.17	258.50
280	22.4	138.87	8.99	275.77	36.10	278.13
300	24.0	148.68	10.31	294.81	41.37	297.70
320	25.6	158.47	11.72	313.70	46.99	317.20
340	27.2	168.24	13.23	332.46	52.95	336.65
360	28.8°	177.98	14.81	351.06	59.25	356.02

SPIRAL FOR 18°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	5.4°	29.87	0.47	59.95	1.88	59.98
80	7.2	39.82	0.83	79.87	3.35	79.94
100	9.0	49.75	1.29	99.75	5.23	99.89
120	10.8	59.69	1.86	119.58	7.52	119.81
140	12.6	69.60	2.53	139.33	10.23	139.70
160	14.4	79.51	3.30	159.00	13.34	159.56
180	16.2	89.40	4.18	178.57	16.87	179.37
200	18.0	99.28	5.16	198.05	20.80	199.14
220	19.8	109.13	6.23	217.40	25.13	218.85
240	21.6	118.97	7.41	236.63	29.86	238.51
260	23.4	128.78	8.69	255.72	34.98	258.10
280	25.2	138.57	10.07	274.66	40.49	277.63
300	27.0	148.34	11.55	293.44	46.39	297.09
320	28.8	158.07	13.13	312.05	52.67	316.47
340	30.6	167.78	14.81	330.48	59.32	335.76
360	32.4°	177.45	16.59	348.72	66.34	354.97

SPIRAL FOR 20°00′ CURVE

l_c	s_c	q	p	y_c	x_c	C
60	6.0°	29.84	0.52	59.93	2.09	59.97
80	8.0	39.77	0.92	79.85	3.72	79.93
100	10.0	49.70	1.43	99.70	5.81	99.87
120	12.0	59.61	2.06	119.48	8.35	119.77
140	14.0	69.51	2.80	139.17	11.35	139.63
160	16.0	79.40	3.66	158.76	14.81	159.45
180	18.0	89.26	4.63	178.24	18.72	179.22
200	20.0	99.11	5.71	197.59	23.07	198.93
220	22.0	108.93	6.90	216.80	27.87	218.58
240	24.0	118.73	8.20	235.85	33.10	238.16
260	26.0	128.50	9.62	254.73	38.76	257.66
280	28.0	138.24	11.15	273.42	44.85	277.08
300	30.0	147.95	12.78	291.92	51.36	296.41
320	32.0	157.63	14.52	310.21	58.28	315.64
340	34.0	167.27	16.38	328.28	65.60	334.77
360	36.0°	176.87	18.34	346.12	73.33	353.80

	2	3	4	5	6	7	8	9	10
′	°′.′	°′.′	°′.′	°′.′	°′.′	°′.′	°′.′	°′.′	°′.′
2	00.1	00.2	00.3	00.5	00.7	01.0	01.3	01.6	02.0
4	00.2	00.4	00.6	01.0	01.4	02.0	02.6	03.2	04.0
6	00.2	00.5	01.0	01.5	02.2	02.9	03.8	04.9	06.0
8	00.3	00.7	01.3	02.0	02.9	03.9	05.1	06.5	08.0
0	0 00.4	0 00.9	0 01.6	0 02.5	0 03.6	0 04.9	0 06.4	0 08.1	0 10.0
2	00.5	01.1	01.9	03.0	04.3	05.9	07.7	09.7	12.0
4	00.6	01.3	02.2	03.5	05.0	06.9	09.0	11.3	14.0
6	00.6	01.4	02.6	04.0	05.8	07.8	10.2	13.0	16.0
8	00.7	01.6	02.9	04.5	06.5	08.8	11.5	14.6	18.0
0	0 00.8	0 01.8	0 03.2	0 05.0	0 07.2	0 09.8	0 12.8	0 16.2	0 20.0
2	00.9	02.0	03.5	05.5	07.9	10.8	14.1	17.8	22.0
4	01.0	02.2	03.8	06.0	08.6	11.8	15.4	19.4	24.0
6	01.0	02.3	04.2	06.5	09.4	12.7	16.6	21.1	26.0
8	01.1	02.5	04.5	07.0	10.1	13.7	17.9	22.7	28.0
0	0 01.2	0 02.7	0 04.8	0 07.5	0 10.8	0 14.7	0 19.2	0 24.3	0 30.0
2	01.3	02.9	05.1	08.0	11.5	15.7	20.5	25.9	32.0
4	01.4	03.1	05.4	08.5	12.2	16.7	21.8	27.5	34.0
6	01.4	03.2	05.8	09.0	13.0	17.6	23.0	29.2	36.0
8	01.5	03.4	06.1	09.5	13.7	18.6	24.3	30.8	38.0
0	0 01.6	0 03.6	0 06.4	0 10.0	0 14.4	0 19.6	0 25.6	0 32.4	0 40.0
2	01.7	03.8	06.7	10.5	15.1	20.6	26.9	34.0	42.0
4	01.8	04.0	07.0	11.0	15.8	21.6	28.2	35.6	44.0
6	01.8	04.1	07.4	11.5	16.6	22.5	29.4	37.3	46.0
8	01.9	04.3	07.7	12.0	17.3	23.5	30.7	38.9	48.0
0	0 02.0	0 04.5	0 08.0	0 12.5	0 18.0	0 24.5	0 32.0	0 40.5	0 50.0
2	02.1	04.7	08.3	13.0	18.7	25.5	33.3	42.1	52.0
4	02.2	04.9	08.6	13.5	19.4	26.5	34.6	43.7	54.0
6	02.2	05.0	09.0	14.0	20.2	27.4	35.8	45.4	56.0
8	02.3	05.2	09.3	14.5	20.9	28.4	37.1	47.0	58.0
0	0 02.4	0 05.4	0 09.6	0 15.0	0 21.6	0 29.4	0 38.4	0 48.6	1 00.0
2	02.5	05.6	09.9	15.5	22.3	30.4	39.7	50.2	02.0
4	02.6	05.8	10.2	16.0	23.0	31.4	41.0	51.8	04.0
6	02.6	05.9	10.6	16.5	23.8	32.3	42.2	53.5	06.0
8	02.7	06.1	10.9	17.0	24.5	33.3	43.5	55.1	08.0
0	0 02.8	0 06.3	0 11.2	0 17.5	0 25.2	0 34.3	0 44.8	0 56.7	1 10.0
2	02.9	06.5	11.5	18.0	25.9	35.3	46.1	58.3	12.0
4	03.0	06.7	11.8	18.5	26.6	36.3	47.4	59.9	14.0
6	03.0	06.8	12.2	19.0	27.4	37.2	48.6	1 01.6	16.0
8	03.1	07.0	12.5	19.5	28.1	38.2	49.9	03.2	18.0
0	0 03.2	0 07.2	0 12.8	0 20.0	0 28.8	0 39.2	0 51.2	1 04.8	1 20.0
2	03.3	07.4	13.1	20.5	29.5	40.2	52.5	06.4	22.0
4	03.4	07.6	13.4	21.0	30.2	41.2	53.8	08.0	24.0
6	03.4	07.7	13.8	21.5	31.0	42.1	55.0	09.7	26.0
8	03.5	07.9	14.1	22.0	31.7	43.1	56.3	11.3	28.0
0	0 03.6	0 08.1	0 14.4	0 22.5	0 32.4	0 44.1	0 57.6	1 12.9	1 30.0
2	03.7	08.3	14.7	23.0	33.1	45.1	58.9	14.5	32.0
4	03.8	08.5	15.0	23.5	33.8	46.1	1 00.2	16.1	34.0
6	03.8	08.6	15.4	24.0	34.6	47.0	01.4	17.8	36.0
8	03.9	08.8	15.7	24.5	35.3	48.0	02.7	19.4	38.0
0	0 04.0	0 09.0	0 16.0	0 25.0	0 36.0	0 49.0	1 04.0	1 21.0	1 40.0
2	04.1	09.2	16.3	25.5	36.7	50.0	05.3	22.6	42.0
4	04.2	09.4	16.6	26.0	37.4	51.0	06.6	24.2	44.0
6	04.2	09.5	17.0	26.5	38.2	51.9	07.8	25.9	46.0
8	04.3	09.7	17.3	27.0	38.9	52.9	09.1	27.5	48.0
0	0 04.4	0 09.9	0 17.6	0 27.5	0 39.6	0 53.9	1 10.4	1 29.1	1 50.0
2	04.5	10.1	17.9	28.0	40.3	54.9	11.7	30.7	52.0
4	04.6	10.3	18.2	28.5	41.0	55.9	13.0	32.3	54.0
6	04.6	10.4	18.6	29.0	41.8	56.8	14.2	34.0	56.0
8	04.7	10.6	18.9	29.5	42.5	57.8	15.5	35.6	58.0
0	0 04.8	0 10.8	0 19.2	0 30.0	0 43.2	0 58.8	1 16.8	1 37.2	2 00.0
	2	3	4	5	6	7	8	9	10

Sc	1	2	3	4	5	6	7	8	9
6.0°	0°01.20′	0°04.8′	0°10.8′	0°19.2′	0°30.0′	0°43.2′	0°58.8′	1°16.8′	1°37.2′
.1	01.22	04.9	11.0	19.5	30.5	43.9	59.8	18.1	38.8
.2	01.24	05.0	11.2	19.8	31.0	44.6	1 00.8	19.4	40.4
.3	01.26	05.0	11.3	20.2	31.5	45.4	01.7	20.6	42.1
.4	01.28	05.1	11.5	20.5	32.0	46.1	02.7	21.9	43.7
.5	0 01.30	0 05.2	0 11.7	0 20.8	0 32.5	0 46.8	1 03.7	1 23.2	1 45.3
.6	01.32	05.3	11.9	21.1	33.0	47.5	04.7	24.5	46.9
.7	01.34	05.4	12.1	21.4	33.5	48.2	05.7	25.8	48.5
.8	01.36	05.4	12.2	21.8	34.0	49.0	06.6	27.0	50.2
.9	01.38	05.5	12.4	22.1	34.5	49.7	07.6	28.3	51.8
7.0	0 01.40	0 05.6	0 12.6	0 22.4	0 35.0	0 50.4	1 08.6	1 29.6	1 53.4
.1	01.42	05.7	12.8	22.7	35.5	51.1	09.6	30.9	55.0
.2	01.44	05.8	13.0	23.0	36.0	51.8	10.6	32.2	56.6
.3	01.46	05.8	13.1	23.4	36.5	52.6	11.5	33.4	58.3
.4	01.48	05.9	13.3	23.7	37.0	53.3	12.5	34.7	59.9
.5	0 01.50	0 06.0	0 13.5	0 24.0	0 37.5	0 54.0	1 13.5	1 36.0	2 01.5
.6	01.52	06.1	13.7	24.3	38.0	54.7	14.5	37.3	03.1
.7	01.54	06.2	13.9	24.6	38.5	55.4	15.5	38.6	04.7
.8	01.56	06.2	14.0	25.0	39.0	56.2	16.4	39.8	06.4
.9	01.58	06.3	14.2	25.3	39.5	56.9	17.4	41.1	08.0
8.0	0 01.60	0 06.4	0 14.4	0 25.6	0 40.0	0 57.6	1 18.4	1 42.4	2 09.6
.1	01.62	06.5	14.6	25.9	40.5	58.3	19.4	43.7	11.2
.2	01.64	06.6	14.8	26.2	41.0	59.0	20.4	45.0	12.8
.3	01.66	06.6	14.9	26.6	41.5	59.8	21.3	46.2	14.5
.4	01.68	06.7	15.1	26.9	42.0	1 00.5	22.3	47.5	16.1
.5	0 01.70	0 06.8	0 15.3	0 27.2	0 42.5	1 01.2	1 23.3	1 48.8	2 17.7
.6	01.72	06.9	15.5	27.5	43.0	01.9	24.3	50.1	19.3
.7	01.74	07.0	15.7	27.8	43.5	02.6	25.3	51.4	20.9
.8	01.76	07.0	15.8	28.2	44.0	03.4	26.2	52.6	22.6
.9	01.78	07.1	16.0	28.5	44.5	04.1	27.2	53.9	24.2
9.0	0 01.80	0 07.2	0 16.2	0 28.8	0 45.0	1 04.8	1 28.2	1 55.2	2 25.8
.1	01.82	07.3	16.4	29.1	45.5	05.5	29.2	56.5	27.4
.2	01.84	07.4	16.6	29.4	46.0	06.2	30.2	57.8	29.0
.3	01.86	07.4	16.7	29.8	46.5	07.0	31.1	59.0	30.7
.4	01.88	07.5	16.9	30.1	47.0	07.7	32.1	2 00.3	32.3
.5	0 01.90	0 07.6	0 17.1	0 30.4	0 47.5	1 08.4	1 33.1	2 01.6	2 33.9
.6	01.92	07.7	17.3	30.7	48.0	09.1	34.1	02.9	35.5
.7	01.94	07.8	17.5	31.0	48.5	09.8	35.1	04.2	37.1
.8	01.96	07.8	17.6	31.4	49.0	10.6	36.0	05.4	38.8
.9	01.98	07.9	17.8	31.7	49.5	11.3	37.0	06.7	40.4
10.0	0 02.00	0 08.0	0 18.0	0 32.0	0 50.0	1 12.0	1 38.0	2 08.0	2 42.0
.1	02.02	08.1	18.2	32.3	50.5	12.7	39.0	09.3	43.6
.2	02.04	08.2	18.4	32.6	51.0	13.4	40.0	10.6	45.2
.3	02.06	08.2	18.5	33.0	51.5	14.2	40.9	11.8	46.8
.4	02.08	08.3	18.7	33.3	52.0	14.9	41.9	13.1	48.5
.5	0 02.10	0 08.4	0 18.9	0 33.6	0 52.5	1 15.6	1 42.9	2 14.4	2 50.1
.6	02.12	08.5	19.1	33.9	53.0	16.3	43.9	15.7	51.7
.7	02.14	08.6	19.3	34.2	53.5	17.0	44.9	17.0	53.3
.8	02.16	08.6	19.4	34.6	54.0	17.8	45.8	18.2	54.9
.9	02.18	08.7	19.6	34.9	54.5	18.5	46.8	19.5	56.6
11.0	0 02.20	0 08.8	0 19.8	0 35.2	0 55.0	1 19.2	1 47.8	2 20.8	2 58.2
.1	02.22	08.9	20.0	35.5	55.5	19.9	48.8	22.1	59.8
.2	02.24	09.0	20.2	35.8	56.0	20.6	49.8	23.4	3 01.4
.3	02.26	09.0	20.3	36.2	56.5	21.4	50.7	24.6	03.0
.4	02.28	09.1	20.5	36.5	57.0	22.1	51.7	25.9	04.7
.5	0 02.30	0 09.2	0 20.7	0 36.8	0 57.5	1 22.8	1 52.7	2 27.2	3 06.3
.6	02.32	09.3	20.9	37.1	58.0	23.5	53.7	28.5	07.9
.7	02.34	09.4	21.1	37.4	58.5	24.2	54.7	29.7	09.5
.8	02.36	09.4	21.2	37.8	59.0	25.0	55.6	31.0	11.1
.9	02.38	09.5	21.4	38.1	59.5	25.7	56.6	32.3	12.7
12.0	0 02.40	0 09.6	0 21.6	0 38.4	1 00.0	1 26.4	1 57.6	2 33.6	3 14.4
	1	2	3	4	5	6	7	8	9

TABLE VII. — DEFLECTION ANGLES TO CHORD POINTS OF SPIRAL

Sc	1	2	3	4	5	6	7	8	9	10
12.0°	0°02.40′	0°09.6′	0°21.6′	0°38.4′	1°00.0′	1°26.4′	1°57.6′	2°33.6′	3°14.4′	3°59.9′
.1	02.42	09.7	21.8	38.7	00.5	27.1	58.6	34.9	16.0	4 01.9
.2	02.44	09.8	22.0	39.0	01.0	27.8	59.5	36.1	17.6	03.9
.3	02.46	09.8	22.1	39.4	01.5	28.6	2 00.5	37.4	19.2	05.9
.4	02.48	09.9	22.3	39.7	02.0	29.3	01.5	38.7	20.8	07.9
.5	0 02.50	0 10.0	0 22.5	0 40.0	1 02.5	1 30.0	2 02.5	2 40.0	3 22.5	4 09.9
.6	02.52	10.1	22.7	40.3	03.0	30.7	03.5	41.3	24.1	11.9
.7	02.54	10.2	22.9	40.6	03.5	31.4	04.4	42.5	25.7	13.9
.8	02.56	10.2	23.0	41.0	04.0	32.2	05.4	43.8	27.3	15.9
.9	02.58	10.3	23.2	41.3	04.5	32.9	06.4	45.1	28.9	17.9
13.0	0 02.60	0 10.4	0 23.4	0 41.6	1 05.0	1 33.6	2 07.4	2 46.4	3 30.5	4 19.9
.1	02.62	10.5	23.6	41.9	05.5	34.3	08.4	47.7	32.2	21.9
.2	02.64	10.6	23.8	42.2	06.0	35.0	09.3	48.9	33.8	23.9
.3	02.66	10.6	23.9	42.6	06.5	35.8	10.3	50.2	35.4	25.9
.4	02.68	10.7	24.1	42.9	07.0	36.5	11.3	51.5	37.0	27.9
.5	0 02.70	0 10.8	0 24.3	0 43.2	1 07.5	1 37.2	2 12.3	2 52.8	3 38.6	4 29.9
.6	02.72	10.9	24.5	43.5	08.0	37.9	13.3	54.0	40.3	31.9
.7	02.74	11.0	24.7	43.8	08.5	38.6	14.2	55.3	41.9	33.9
.8	02.76	11.0	24.8	44.2	09.0*	39.4	15.2	56.6	43.5	35.9
.9	02.78	11.1	25.0	44.5	09.5	40.1	16.2	57.9	45.1	37.9
14.0	0 02.80	0 11.2	0 25.2	0 44.8	1 10.0	1 40.8	2 17.2	2 59.2	3 46.7	4 39.9
.1	02.82	11.3	25.4	45.1	10.5	41.5	18.2	3 00.4	48.4	41.9
.2	02.84	11.4	25.6	45.4	11.0	42.2	19.1	01.7	50.0	43.9
.3	02.86	11.4	25.7	45.8	11.5	43.0	20.1	03.0	51.6	45.9
.4	02.88	11.5	25.9	46.1	12.0	43.7	21.1	04.3	53.2	47.9
.5	0 02.90	0 11.6	0 26.1	0 46.4	1 12.5	1 44.4	2 22.1	3 05.6	3 54.8	4 49.9
.6	02.92	11.7	26.3	46.7	13.0	45.1	23.1	06.8	56.4	51.9
.7	02.94	11.8	26.5	47.0	13.5	45.8	24.0	08.1	58.1	53.9
.8	02.96	11.8	26.6	47.4	14.0	46.6	25.0	09.4	59.7	55.8
.9	02.98	11.9	26.8	47.7	14.5	47.3	26.0	10.7	4 01.3	57.8
15.0	0 03.00	0 12.0	0 27.0	0 48.0	1 15.0	1 48.0	2 27.0	3 12.0	4 02.9	4 59.8
.1	03.02	12.1	27.2	48.3	15.5	48.7	28.0	13.2	04.5	5 01.8
.2	03.04	12.2	27.4	48.6	16.0	49.4	28.9	14.5	06.1	03.8
.3	03.06	12.2	27.5	49.0	16.5	50.2	29.9	15.8	07.8	05.8
.4	03.08	12.3	27.7	49.3	17.0	50.9	30.9	17.1	09.4	07.8
.5	0 03.10	0 12.4	0 27.9	0 49.6	1 17.5	1 51.6	2 31.9	3 18.4	4 11.0	5 09.8
.6	03.12	12.5	28.1	49.9	18.0	52.3	32.9	19.6	12.6	11.8
.7	03.14	12.6	28.3	50.2	18.5	53.0	33.8	20.9	14.2	13.8
.8	03.16	12.6	28.4	50.6	19.0	53.7	34.8	22.2	15.9	15.8
.9	03.18	12.7	28.6	50.9	19.5	54.5	35.8	23.5	17.5	17.8
16.0	0 03.20	0 12.8	0 28.8	0 51.2	1 20.0	1 55.2	2 36.8	3 24.8	4 19.1	5 19.8
.1	03.22	12.9	29.0	51.5	20.5	55.9	37.8	26.0	20.7	21.8
.2	03.24	13.0	29.2	51.8	21.0	56.6	38.7	27.3	22.3	23.8
.3	03.26	13.0	29.3	52.2	21.5	57.3	39.7	28.6	23.9	25.8
.4	03.28	13.1	29.5	52.5	22.0	58.1	40.7	29.9	25.6	27.8
.5	0 03.30	0 13.2	0 29.7	0 52.8	1 22.5	1 58.8	2 41.7	3 31.1	4 27.2	5 29.8
.6	03.32	13.3	29.9	53.1	23.0	59.5	42.7	32.4	28.8	31.8
.7	*03.34	13.4	30.1	53.4	23.5	2 00.2	43.6	33.7	30.4	33.8
.8	03.36	13.4	30.2	53.8	24.0	00.9	44.6	35.0	32.0	35.8
.9	03.38	13.5	30.4	54.1	24.5	01.7	45.6	36.3	33.6	37.8
17.0	0 03.40	0 13.6	0 30.6	0 54.4	1 25.0	2 02.4	2 46.6	3 37.5	4 35.3	5 39.8
.1	03.42	13.7	30.8	54.7	25.5	03.1	47.5	38.8	36.9	41.8
.2	03.44	13.8	31.0	55.0	26.0	03.8	48.5	40.1	38.5	43.7
.3	03.46	13.8	31.1	55.4	26.5	04.5	49.5	41.4	40.1	45.7
.4	03.48	13.9	31.3	55.7	27.0	05.3	50.5	42.7	41.7	47.7
.5	0 03.50	0 14.0	0 31.5	0 56.0	1 27.5	2 06.0	2 51.5	3 43.9	4 43.4	5 49.7
.6	03.52	14.1	31.7	56.3	28.0	06.7	52.4	45.2	45.0	51.7
.7	03.54	14.2	31.9	56.6	28.5	07.4	53.4	46.5	46.6	53.7
.8	03.56	14.2	32.0	57.0	29.0	08.1	54.4	47.8	48.2	55.7
.9	03.58	14.3	32.2	57.3	29.5	08.9	55.4	49.0	49.8	57.7
18.0	0 03.60	0 14.4	0 32.4	0 57.6	1 30.0	2 09.6	2 56.4	3 50.3	4 51.5	5 59.7
	1	2	3	4	5	6	7	8	9	10

Sc	1	2	3	4	5	6	7	8	9	1
18.0°	0°03.60′	0°14.4′	0°32.4′	0°57.6′	1°30.0′	2°09.6′	2°56.4′	3°50.3′	4°51.5′	5°
.1	03.62	14.5	32.6	57.9	30.5	10.3	57.3	51.6	53.1	6
.2	03.64	14.6	32.8	58.2	31.0	11.0	58.3	52.9	54.7	
.3	03.66	14.6	32.9	58.6	31.5	11.7	59.3	54.2	56.3	
.4	03.68	14.7	33.1	58.9	32.0	12.5	3 00.3	55.4	57.9	
.5	0 03.70	0 14.8	0 33.3	0 59.2	1 32.5	2 13.2	3 01.3	3 56.7	4 59.5	6
.6	03.72	14.9	33.5	59.5	33.0	13.9	02.2	58.0	5 01.2	
.7	03.74	15.0	33.7	59.8	33.5	14.6	03.2	59.3	02.8	
.8	03.76	15.0	33.8	1 00.2	34.0	15.3	04.2	4 00.6	04.4	
.9	03.78	15.1	34.0	00.5	34.5	16.1	05.2	01.8	06.0	
19.0	0 03.80	0 15.2	0 34.2	1 00.8	1 35.0	2 16.8	3 06.2	4 03.1	5 07.6	6
.1	03.82	15.3	34.4	01.1	35.5	17.5	07.1	04.4	09.2	
.2	03.84	15.4	34.6	01.4	36.0	18.2	08.1	05.7	10.9	
.3	03.86	15.4	34.7	01.8	36.5	18.9	09.1	06.9	12.5	
.4	03.88	15.5	34.9	02.1	37.0	19.7	10.1	08.2	14.1	
.5	0 03.90	0 15.6	0 35.1	1 02.4	1 37.5	2 20.4	3 11.1	4 09.5	5 15.7	6
.6	03.92	15.7	35.3	02.7	38.0	21.1	12.0	10.8	17.3	
.7	03.94	15.8	35.5	03.0	38.5	21.8	13.0	12.1	18.9	
.8	03.96	15.8	35.6	03.4	39.0	22.5	14.0	13.3	20.6	
.9	03.98	15.9	35.8	03.7	39.5	23.3	15.0	14.6	22.2	
20.0	0 04.00	0 16.0	0 36.0	1 04.0	1 40.0	2 24.0	3 16.0	4 15.9	5 23.8	6
.1	04.02	16.1	36.2	04.3	40.5	24.7	16.9	17.2	25.4	
.2	04.04	16.2	36.4	04.6	41.0	25.4	17.9	18.5	27.0	
.3	04.06	16.2	36.5	05.0	41.5	26.1	18.9	19.7	28.6	
.4	04.08	16.3	36.7	05.3	42.0	26.9	19.9	21.0	30.3	
.5	0 04.10	0 16.4	0 36.9	1 05.6	1 42.5	2 27.6	3 20.9	4 22.3	5 31.9	6
.6	04.12	16.5	37.1	05.9	43.0	28.3	21.8	23.6	33.5	
.7	04.14	16.6	37.3	06.2	43.5	29.0	22.8	24.8	35.1	
.8	04.16	16.6	37.4	06.6	44.0	29.7	23.8	26.1	36.7	
.9	04.18	16.7	37.6	06.9	44.5	30.5	24.8	27.4	38.3	
21.0	0 04.20	0 16.8	0 37.8	1 07.2	1 45.0	2 31.2	3 25.8	4 28.7	5 40.0	6
.2	04.24	17.0	38.2	07.8	46.0	32.6	27.7	31.2	43.2	7
.4	04.28	17.1	38.5	08.5	47.0	34.1	29.7	33.8	46.4	
.6	04.32	17.3	38.9	09.1	48.0	35.5	31.6	36.4	49.7	
.8	04.36	17.4	39.2	09.8	49.0	37.0	33.6	38.9	52.9	
22.0	0 04.40	0 17.6	0 39.6	1 10.4	1 50.0	2 38.4	3 35.5	4 41.5	5 56.1	7
.2	04.44	17.8	40.0	11.0	51.0	39.8	37.5	44.0	59.3	
.4	04.48	17.9	40.3	11.7	52.0	41.3	39.5	46.6	6 02.6	
.6	04.52	18.1	40.7	12.3	53.0	42.7	41.4	49.1	05.8	
.8	04.56	18.2	41.0	13.0	54.0	44.2	43.4	51.7	09.0	
23.0	0 04.60	0 18.4	0 41.4	1 13.6	1 55.0	2 45.6	3 45.3	4 54.2	6 12.3	7
.2	04.64	18.6	41.8	14.2	56.0	47.0	47.3	56.8	15.5	
.4	04.68	18.7	42.1	14.9	57.0	48.5	49.2	59.4	18.7	
.6	04.72	18.9	42.5	15.5	58.0	49.9	51.2	5 01.9	22.0	
.8	04.76	19.0	42.8	16.2	59.0	51.4	53.2	04.5	25.2	
24.0	0 04.80	0 19.2	0 43.2	1 16.8	2 00.0	2 52.8	3 55.1	5 07.0	6 28.4	7
.2	04.84	19.4	43.6	17.4	01.0	54.2	57.1	09.6	31.7	8
.4	04.88	19.5	43.9	18.1	02.0	55.7	59.0	12.1	34.9	
.6	04.92	19.7	44.3	18.7	03.0	57.1	4 01.0	14.7	38.1	
.8	04.96	19.8	44.6	19.4	04.0	58.6	03.0	17.2	41.3	
25.0	0 05.00	0 20.0	0 45.0	1 20.0	2 05.0	3 00.0	4 04.9	5 19.8	6 44.6	8
.2	05.04	20.2	45.4	20.6	06.0	01.4	06.9	22.4	47.8	
.4	05.08	20.3	45.7	21.3	07.0	02.9	08.8	24.9	51.0	
.6	05.12	20.5	46.1	21.9	08.0	04.3	10.8	27.5	54.3	
.8	05.16	20.6	46.4	22.6	09.0	05.8	12.8	30.0	57.5	
26.0	0 05.20	0 20.8	0 46.8	1 23.2	2 10.0	3 07.2	4 14.7	5 32.6	7 00.7	8
.2	05.24	21.0	47.2	23.8	11.0	08.6	16.7	35.1	04.0	
.4	05.28	21.1	47.5	24.5	12.0	10.1	18.6	37.7	07.2	
.6	05.32	21.3	47.9	25.1	13.0	11.5	20.6	40.2	10.4	
.8	05.36	21.4	48.2	25.8	14.0	13.0	22.5	42.8	13.7	
27.0	0 05.40	0 21.6	0 48.6	1 26.4	2 15.0	3 14.4	4 24.5	5 45.4	7 16.9	8
	1	2	3	4	5	6	7	8	9	1

	1	2	3	4	5	6	7	8	9	10
	0°05.40′	0°21.6′	0°48.6′	1°26.4′	2°15.0′	3°14.4′	4°24.5′	5°45.4′	7°16.9′	8°59.0′
	05.44	21.8	49.0	27.0	16.0	15.8	26.5	47.9	20.1	9 03.0
	05.48	21.9	49.3	27.7	17.0	17.3	28.4	50.5	23.3	07.0
	05.52	22.1	49.7	28.3	18.0	18.7	30.4	53.0	26.6	11.0
	05.56	22.2	50.0	29.0	19.0	20.1	32.3	55.6	29.8	14.9
	0 05.60	0 22.4	0 50.4	1 29.6	2 20.0	3 21.5	4 34.3	5 58.1	7 33.0	9 18.9
	05.64	22.6	50.8	30.2	21.0	23.0	36.2	6 00.7	36.3	22.9
	05.68	22.7	51.1	30.9	22.0	24.4	38.2	03.2	39.5	26.9
	05.72	22.9	51.5	31.5	23.0	25.9	40.2	05.8	42.7	30.9
	05.76	23.0	51.8	32.2	24.0	27.3	42.1	08.3	45.9	34.8
	0 05.80	0 23.2	0 52.2	1 32.8	2 25.0	3 28.8	4 44.1	6 10.9	7 49.2	9 38.8
	05.84	23.4	52.6	33.4	26.0	30.2	46.0	13.4	52.4	42.8
	05.88	23.5	52.9	34.1	27.0	31.6	48.0	16.0	55.6	46.8
	05.92	23.7	53.3	34.7	28.0	33.1	49.9	18.6	58.8	50.7
	05.96	23.8	53.6	35.4	29.0	34.5	51.9	21.1	8 02.1	54.7
	0 06.00	0 24.0	0 54.0	1 36.0	2 30.0	3 35.9	4 53.9	6 23.7	8 05.3	9 58.7
	06.04	24.2	54.4	36.6	31.0	37.4	55.8	26.2	08.5	10 02.6
	06.08	24.3	54.7	37.3	32.0	38.8	57.8	28.8	11.7	06.6
	06.12	24.5	55.1	37.9	33.0	40.3	59.7	31.3	15.0	10.6
	06.16	24.6	55.4	38.6	34.0	41.7	5 01.7	33.9	18.2	14.6
	0 06.20	0 24.8	0 55.8	1 39.2	2 35.0	3 43.1	5 03.6	6 36.4	8 21.4	10 18.5
	06.24	25.0	56.2	39.8	36.0	44.6	05.6	39.0	24.6	22.5
	06.28	25.1	56.5	40.5	37.0	46.0	07.5	41.5	27.9	26.5
	06.32	25.3	56.9	41.1	38.0	47.5	09.5	44.1	31.1	30.4
	06.36	25.4	57.2	41.8	39.0	48.9	11.5	46.6	34.3	34.4
	0 06.40	0 25.6	0 57.6	1 42.4	2 40.0	3 50.3	5 13.4	6 49.2	8 37.5	10 38.4
	06.44	25.8	58.0	43.0	41.0	51.8	15.4	51.7	40.8	42.4
	06.48	25.9	58.3	43.7	42.0	53.2	17.3	54.3	44.0	46.3
	06.52	26.1	58.7	44.3	43.0	54.7	19.3	56.8	47.2	50.3
	06.56	26.2	59.0	45.0	44.0	56.1	21.2	59.4	50.4	54.3
	0 06.60	0 26.4	0 59.4	1 45.6	2 45.0	3 57.5	5 23.2	7 01.9	8 53.7	10 58.2
	06.64	26.6	59.8	46.2	46.0	59.0	25.1	04.5	56.9	11 02.2
	06.68	26.7	1 00.1	46.9	47.0	4 00.4	27.1	07.0	9 00.1	06.2
	06.72	26.9	00.5	47.5	48.0	01.8	29.1	09.6	03.3	10.1
	06.76	27.0	00.8	48.2	49.0	03.3	31.0	12.1	06.5	14.1
	0 06.80	0 27.2	1 01.2	1 48.8	2 50.0	4 04.7	5 33.0	7 14.7	9 09.8	11 18.1
	06.84	27.4	01.6	49.4	51.0	06.2	34.9	17.2	13.0	22.0
	06.88	27.5	01.9	50.1	52.0	07.6	36.9	19.8	16.2	26.0
	06.92	27.7	02.3	50.7	53.0	09.0	38.8	22.4	19.4	30.0
	06.96	27.8	02.6	51.4	54.0	10.5	40.8	24.9	22.7	33.9
	0 07.00	0 28.0	1 03.0	1 52.0	2 55.0	4 11.9	5 42.8	7 27.5	9 25.9	11 37.9
	07.04	28.2	03.4	52.6	56.0	13.3	44.7	30.0	29.1	41.8
	07.08	28.3	03.7	53.3	57.0	14.8	46.7	32.6	32.3	45.8
	07.12	28.5	04.1	53.9	58.0	16.2	48.6	35.1	35.5	49.8
	07.16	28.6	04.4	54.6	59.0	17.7	50.6	37.7	38.8	53.7
	0 07.20	0 28.8	1 04.8	1 55.2	3 00.0	4 19.1	5 52.5	7 40.2	9 42.0	11 57.7
	07.24	29.0	05.2	55.8	01.0	20.5	54.5	42.8	45.2	12 01.7
	07.28	29.1	05.5	56.5	02.0	22.0	56.5	45.3	48.4	05.6
	07.32	29.3	05.9	57.1	03.0	23.4	58.4	47.8	51.6	09.6
	07.36	29.4	06.2	57.8	04.0	24.8	6 00.4	50.4	54.9	13.5
	0 07.40	0 29.6	1 06.6	1 58.4	3 05.0	4 26.3	6 02.3	7 52.9	9 58.1	12 17.5
	07.44	29.8	07.0	59.0	06.0	27.7	04.3	55.5	10 01.3	21.5
	07.48	29.9	07.3	59.7	07.0	29.2	06.2	58.0	04.5	25.4
	07.52	30.1	07.7	2 00.3	08.0	30.6	08.2	8 00.6	07.7	29.4
	07.56	30.2	08.0	01.0	09.0	32.0	10.1	03.1	11.0	33.3
	0 07.60	0 30.4	1 08.4	2 01.6	3 10.0	4 33.5	6 12.1	8 05.7	10 14.2	12 37.3
	07.64	30.6	08.8	02.2	11.0	34.9	14.0	08.2	17.4	41.2
	07.68	30.7	09.1	02.9	12.0	36.3	16.0	10.8	20.6	45.2
	07.72	30.9	09.5	03.5	13.0	37.8	18.0	13.3	23.8	49.2
	07.76	31.0	09.8	04.2	14.0	39.2	19.9	15.9	27.0	53.1
	0 07.80	0 31.2	1 10.2	2 04.8	3 15.0	4 40.7	6 21.9	8 18.4	10 30.2	12 57.1
	1	2	3	4	5	6	7	8	9	10

TABLE VII. — DEFLECTION ANGLES TO CHORD POINTS OF

Sc	1	2	3	4	5	6	7	8	9
39.0°	0°07.80′	0°31.2′	1°10.2′	2°04.8′	3°15.0′	4°40.7′	6°21.9′	8°18.4′	10°3
.2	07.84	31.4	10.6	05.4	16.0	42.1	23.8	21.0	3
.4	07.88	31.5	10.9	06.1	17.0	43.5	25.8	23.5	3
.6	07.92	31.7	11.3	06.7	18.0	45.0	27.7	26.1	3
.8	07.96	31.8	11.6	07.4	19.0	46.4	29.7	28.6	4
40.0	0 08.00	0 32.0	1 12.0	2 08.0	3 20.0	4 47.9	6 31.6	8 31.2	10 4
.2	08.04	32.2	12.4	08.6	20.9	49.3	33.6	33.7	4
.4	08.08	32.3	12.7	09.3	21.9	50.7	35.5	36.3	5
.6	08.12	32.5	13.1	09.9	22.9	52.2	37.5	38.8	5
.8	08.16	32.6	13.4	10.6	23.9	53.6	39.5	41.4	5
41.0	0 08.20	0 32.8	1 13.8	2 11.2	3 24.9	4 55.0	6 41.4	8 43.9	11 0
.2	08.24	33.0	14.2	11.8	25.9	56.5	43.4	46.5	0
.4	08.28	33.1	14.5	12.5	26.9	57.9	45.3	49.0	0
.6	08.32	33.3	14.9	13.1	27.9	59.4	47.3	51.6	1
.8	08.36	33.4	15.2	13.8	28.9	5 00.8	49.2	54.1	1
42.0	0 08.40	0 33.6	1 15.6	2 14.4	3 29.9	5 02.2	6 51.2	8 56.6	11 1
.2	08.44	33.8	16.0	15.0	30.9	03.7	53.1	59.2	1
.4	08.48	33.9	16.3	15.7	31.9	05.1	55.1	9 01.7	2
.6	08.52	34.1	16.7	16.3	32.9	06.5	57.0	04.3	2
.8	08.56	34.2	17.0	17.0	33.9	08.0	59.0	06.8	3
43.0	0 08.60	0 34.4	1 17.4	2 17.6	3 34.9	5 09.4	7 01.0	9 09.4	11 3
.2	08.64	34.6	17.8	18.2	35.9	10.9	02.9	11.9	3
.4	08.68	34.7	18.1	18.9	36.9	12.3	04.9	14.5	4
.6	08.72	34.9	18.5	19.5	37.9	13.7	06.8	17.0	4
.8	08.76	35.0	18.8	20.2	38.9	15.2	08.8	19.5	4
44.0	0 08.80	0 35.2	1 19.2	2 20.8	3 39.9	5 16.6	7 10.7	9 22.1	11 5
.2	08.84	35.4	19.6	21.4	40.9	18.0	12.7	24.6	5
.4	08.88	35.5	19.9	22.1	41.9	19.5	14.6	27.2	5
.6	08.92	35.7	20.3	22.7	42.9	20.9	16.6	29.7	12 0
.8	08.96	35.8	20.6	23.4	43.9	22.4	18.5	32.3	0
45.0	0 09.00	0 36.0	1 21.0	2 24.0	3 44.9	5 23.8	7 20.5	9 34.8	12 0
	1	2	3	4	5	6	7	8	9

TABLE VII A. — COEFFICIENTS OF i_1 FOR DEFLECTION A TO CHORD POINTS OF SPIRAL

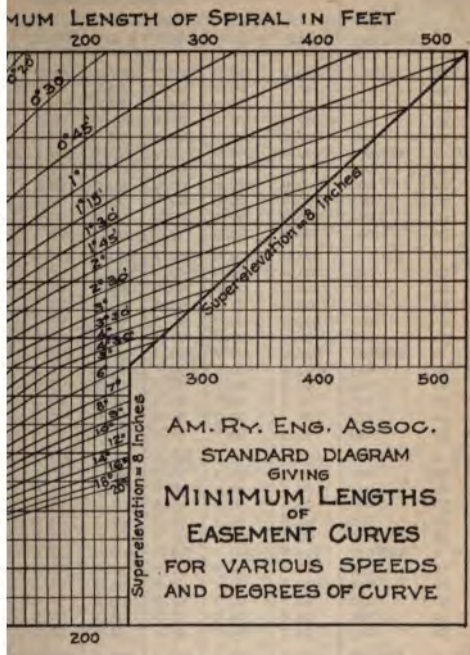
		Transit at Chord Point Number								
		T. S. 0	1	2	3	4	5	6	7	8
Deflection Angle to Chord Point Number	T. S.									
	0	0	2	8	18	32	50	72	98	128
	1	1	0	5	14	27	44	65	90	119
	2	4	4	0	8	20	36	56	80	108
	3	9	10	7	0	11	26	45	68	95
	4	16	18	16	10	0	14	32	54	80
	5	25	28	27	22	13	0	17	38	63
	6	36	40	40	36	28	16	0	20	44
	7	49	54	55	52	45	34	19	0	23
	8	64	70	72	70	64	54	40	22	0
	9	81	88	91	90	85	76	63	46	25
	10 S. C.	100	108	112	112	108	100	88	72	52
		0 T. S.	1	2	3	4	5	6	7	8

TABLE VII B.—SPIRALS—COEFFICIENTS FOR x_c, y_c, p, q

c	$\frac{x_c}{l_c}$	$\frac{y_c}{l_c}$	$p = al_c - bD_c$		$q = el_c - fD_c$		S_c
			a	b	e	f	
'	.000 000	1.000 000	.000 000	.000 00	.500 000	.000 00	0°
30'	.002 909	.999 993	.000 727	.000 00	.499 999	.000 64	30'
'	.005 818	.999 970	.001 454	.000 01	.499 995	.001 27	1°
30'	.008 726	.999 932	.002 182	.000 03	.499 989	.001 91	30'
'	.011 635	.999 879	.002 909	.000 04	.499 980	.002 55	2°
30'	.014 542	.999 811	.003 636	.000 07	.499 969	.003 18	30'
'	.017 450	.999 727	.004 363	.000 10	.499 956	.003 82	3°
30'	.020 357	.999 629	.005 090	.000 14	.499 940	.004 46	30'
'	.023 263	.999 515	.005 817	.000 18	.499 922	.005 09	4°
30'	.026 169	.999 387	.006 544	.000 23	.499 901	.005 73	30'
'	.029 073	.999 243	.007 270	.000 28	.499 877	.006 36	5°
30'	.031 977	.999 084	.007 997	.000 34	.499 852	.007 00	30'
'	.034 880	.998 910	.008 724	.000 40	.499 824	.007 63	6°
30'	.037 781	.998 721	.009 450	.000 47	.499 793	.008 26	30'
'	.040 681	.998 517	.010 176	.000 54	.499 760	.008 90	7°
30'	.043 581	.998 298	.010 902	.000 62	.499 724	.009 53	30'
'	.046 478	.998 063	.011 628	.000 71	.499 686	.010 16	8°
30'	.049 374	.997 814	.012 354	.000 80	.499 646	.010 79	30'
'	.052 269	.997 549	.013 080	.000 90	.499 603	.011 42	9°
30'	.055 162	.997 270	.013 805	.001 00	.499 558	.012 05	30'
'	.058 053	.996 975	.014 530	.001 11	.499 510	.012 68	10°
30'	.060 942	.996 666	.015 255	.001 22	.499 460	.013 30	30'
'	.063 829	.996 341	.015 980	.001 34	.499 407	.013 93	11°
30'	.066 714	.996 002	.016 704	.001 47	.499 352	.014 55	30'
'	.069 598	.995 647	.017 429	.001 60	.499 294	.015 18	12°
30'	.072 478	.995 278	.018 153	.001 73	.499 234	.015 80	30'
'	.075 357	.994 893	.018 877	.001 87	.499 172	.016 42	13°
30'	.078 233	.994 494	.019 600	.002 02	.499 107	.017 04	30'
'	.081 106	.994 079	.020 323	.002 17	.499 040	.017 66	14°
30'	.083 977	.993 650	.021 046	.002 33	.498 970	.018 28	30'
'	.086 846	.993 206	.021 769	.002 49	.498 898	.018 89	15°
30'	.089 711	.992 747	.022 491	.002 65	.498 824	.019 51	30'
'	.092 574	.992 273	.023 213	.002 83	.498 747	.020 12	16°
30'	.095 433	.991 785	.023 935	.003 01	.498 667	.020 73	30'
'	.098 290	.991 281	.024 656	.003 19	.498 585	.021 34	17°
30'	.101 143	.990 763	.025 377	.003 38	.498 501	.021 95	30'
'	.103 993	.990 230	.026 097	.003 57	.498 414	.022 56	18°
30'	.106 840	.989 682	.026 817	.003 77	.498 325	.023 16	30'
'	.109 683	.989 120	.027 537	.003 98	.498 233	.023 77	19°
30'	.112 523	.988 543	.028 257	.004 19	.498 139	.024 37	30'
'	.115 360	.987 951	.028 976	.004 40	.498 043	.024 97	20°
30'	.118 192	.987 344	.029 694	.004 62	.497 944	.025 57	30'
'	.121 021	.986 723	.030 412	.004 85	.497 843	.026 16	21°
30'	.123 846	.986 088	.031 130	.005 08	.497 739	.026 75	30'
'	.126 667	.985 437	.031 847	.005 32	.497 633	.027 35	22°
30'	.129 483	.984 772	.032 564	.005 56	.497 525	.027 94	30'
'	.132 296	.984 093	.033 280	.005 80	.497 414	.028 52	23°
30'	.135 105	.983 399	.033 996	.006 05	.497 300	.029 11	30'
'	.137 909	.982 691	.034 711	.006 31	.497 185	.029 69	24°
30'	.140 708	.981 968	.035 426	.006 57	.497 067	.030 27	30'

TABLE VII.B. — SPIRALS — COEFFICIENTS FOR x_c, y_c, p, q

S_c	$\frac{x_c}{l_c}$	$\frac{y_c}{l_c}$	$p = al_c - bD_c$		$q = el_c - fD_c$	
			a	b	e	f
25°	.143 504	.981 231	.036 140	.006 84	.496 946	.030 85
30′	.146 294	.980 479	.036 854	.007 11	.496 823	.031 43
26°	.149 080	.979 714	.037 567	.007 39	.496 698	.032 00
30′	.151 861	.978 933	.038 280	.007 67	.496 570	.032 57
27°	.154 638	.978 139	.038 992	.007 96	.496 440	.033 14
30′	.157 409	.977 330	.039 704	.008 25	.496 308	.033 71
28°	.160 176	.976 508	.040 415	.008 54	.496 173	.034 27
30′	.162 937	.975 670	.041 125	.008 85	.496 036	.034 83
29°	.165 693	.974 819	.041 835	.009 15	.495 896	.035 39
30′	.168 444	.973 954	.042 544	.009 46	.495 754	.035 95
30°	.171 189	.973 074	.043 253	.009 78	.495 610	.036 50
30′	.173 929	.972 181	.043 961	.010 10	.495 463	.037 05
31°	.176 664	.971 273	.044 668	.010 43	.495 314	.037 60
30′	.179 392	.970 352	.045 375	.010 76	.495 162	.038 14
32°	.182 116	.969 417	.046 081	.011 09	.495 008	.038 68
30′	.184 833	.968 468	.046 787	.011 43	.494 852	.039 22
33°	.187 544	.967 504	.047 491	.011 78	.494 694	.039 76
30′	.190 250	.966 528	.048 195	.012 13	.494 533	.040 29
34°	.192 949	.965 537	.048 899	.012 48	.494 369	.040 82
30′	.195 643	.964 532	.049 602	.012 84	.494 204	.041 35
35°	.198 330	.963 515	.050 304	.013 20	.494 036	.041 87
30′	.201 010	.962 483	.051 005	.013 57	.493 866	.042 39
36°	.203 685	.961 438	.051 705	.013 94	.493 693	.042 91
30′	.206 353	.960 379	.052 405	.014 32	.493 518	.043 42
37°	.209 014	.959 306	.053 104	.014 70	.493 341	.043 93
30′	.211 669	.958 221	.053 803	.015 09	.493 161	.044 44
38°	.214 317	.957 121	.054 500	.015 48	.492 979	.044 94
30′	.216 959	.956 009	.055 197	.015 87	.492 795	.045 44
39°	.219 593	.954 883	.055 893	.016 27	.492 608	.045 94
30′	.222 221	.953 744	.056 589	.016 67	.492 420	.046 43
40°	.224 841	.952 591	.057 283	.017 08	.492 229	.046 92
30′	.227 455	.951 426	.057 977	.017 49	.492 035	.047 41
41°	.230 061	.950 247	.058 670	.017 91	.491 839	.047 89
30′	.232 660	.949 055	.059 362	.018 33	.491 641	.048 37
42°	.235 252	.947 850	.060 053	.018 75	.491 441	.048 85
30′	.237 836	.946 632	.060 743	.019 18	.491 239	.049 32
43°	.240 413	.945 402	.061 433	.019 61	.491 034	.049 79
30′	.242 982	.944 158	.062 122	.020 05	.490 827	.050 25
44°	.245 544	.942 901	.062 809	.020 49	.490 617	.050 71
30′	.248 098	.941 632	.063 496	.020 93	.490 406	.051 17
45°	.250 644	.940 350	.064 182	.021 38	.490 192	.051 62



ich are liable to limit the speed of trains, the length
al that indicated on the line marked "Superelevа-
Longer spirals may be used, provided the increased
ersely affect the degree of curve or seriously affect
tion.

the length of spiral should never be less than that
ıgram; an increase of about 50 per cent over the in-
be desirable when cost is not seriously affected.
be used when superelevation required for highest
less than two inches.

Acres	L'gth. Feet.	Acres	L'gth. Feet.	Acres	L'gth. Feet.	Acres	L'gth. Feet.	A
0.00	2.18	0.60	263.54	1.20	524.90	1.80	786.26	
.01	6.53	.61	267.89	.21	529.25	.81	790.61	
.02	10.89	.62	272.25	.22	533.61	.82	794.97	
.03	15.25	.63	276.61	.23	537.97	.83	799.33	
.04	19.60	.64	280.96	.24	542.32	.84	803.68	
0.05	23.96	0.65	285.32	1.25	546.68	1.85	808.04	
.06	28.31	.66	289.67	.26	551.03	.86	812.39	
.07	32.67	.67	294.03	.27	555.39	.87	816.75	
.08	37.03	.68	298.39	.28	559.75	.88	821.11	
.09	41.38	.69	302.74	.29	564.10	.89	825.46	
0.10	45.74	0.70	307.10	1.30	568.46	1.90	829.82	
.11	50.09	.71	311.45	.31	572.81	.91	834.17	
.12	54.45	.72	315.81	.32	577.17	.92	838.53	
.13	58.81	.73	320.17	.33	581.53	.93	842.89	
.14	63.16	.74	324.52	.34	585.88	.94	847.24	
0.15	67.52	0.75	328.88	1.35	590.24	1.95	851.60	
.16	71.87	.76	333.23	.36	594.59	.96	855.95	
.17	76.23	.77	337.59	.37	598.95	.97	860.31	
.18	80.59	.78	341.95	.38	603.31	.98	864.67	
.19	84.94	.79	346.30	.39	607.66	.99	869.02	
0.20	89.30	0.80	350.66	1.40	612.02	2.00	873.38	
.21	93.65	.81	355.01	.41	616.37	.01	877.73	
.22	98.01	.82	359.37	.42	620.73	.02	882.09	
.23	102.37	.83	363.73	.43	625.09	.03	886.45	
.24	106.72	.84	368.08	.44	629.44	.04	890.80	
0.25	111.08	0.85	372.44	1.45	633.80	2.05	895.16	
.26	115.43	.86	376.79	.46	638.15	.06	899.51	
.27	119.79	.87	381.15	.47	642.51	.07	903.87	
.28	124.15	.88	385.51	.48	646.87	.08	908.23	
.29	128.50	.89	389.86	.49	651.22	.09	912.58	
0.30	132.86	0.90	394.22	1.50	655.58	2.10	916.94	
.31	137.21	.91	398.57	.51	659.93	.11	921.29	
.32	141.57	.92	402.93	.52	664.29	.12	925.65	
.33	145.93	.93	407.29	.53	668.65	.13	930.01	
.34	150.28	.94	411.64	.54	673.00	.14	934.36	
0.35	154.64	0.95	416.00	1.55	677.36	2.15	938.72	
.36	158.99	.96	420.35	.56	681.71	.16	943.07	
.37	163.35	.97	424.71	.57	686.07	.17	947.43	
.38	167.71	.98	429.07	.58	690.43	.18	951.79	
.39	172.06	.99	433.42	.59	694.78	.19	956.14	
0.40	176.42	1.00	437.78	1.60	699.14	2.20	960.50	
.41	180.77	.01	442.13	.61	703.49	.21	964.85	
.42	185.13	.02	446.49	.62	707.85	.22	969.21	
.43	189.49	.03	450.85	.63	712.21	.23	973.57	
.44	193.84	.04	455.10	.64	716.56	.24	977.92	
0.45	198.20	1.05	459.56	1.65	720.92	2.25	982.28	
.46	202.55	.06	463.91	.66	725.27	.26	986.63	
.47	206.91	.07	468.27	.67	729.63	.27	990.99	
.48	211.27	.08	472.63	.68	733.99	.28	995.35	
.49	215.62	.09	476.98	.69	738.34	.29	999.70	
0.50	219.98	1.10	481.34	1.70	742.70	2.30	1004.06	
.51	224.33	.11	485.69	.71	747.05	.31	1008.41	
.52	228.69	.12	490.05	.72	751.41	.32	1012.77	
.53	233.05	.13	494.41	.73	755.77	.33	1017.13	
.54	237.40	.14	498.76	.74	760.12	.34	1021.48	
0.55	241.76	1.15	503.12	1.75	764.48	2.35	1025.84	
.56	246.11	.16	507.47	.76	768.83	.36	1030.19	
.57	250.47	.17	511.83	.77	773.19	.37	1034.55	
.58	254.83	.18	516.19	.78	777.55	.38	1038.91	
.59	259.18	.19	520.54	.79	781.90	.39	1043.26	
0.60	263.54	1.20	524.90	1.80	786.26	2.40	1047.62	

TABLE VIII.—LONG CHORDS AND ACTUAL ARCS.

Degree of Curve.	Actual Arc, One Station.	LONG CHORDS. 2 Sta.	3 Sta.	4 Sta.	5 Sta.	6 Sta.	7 Sta.	8 Sta.	Degree of Curve.
10° 0′	100.127	199.2	297.0	392.4	484.9	573.7	658.1	737.5	10° 0′
10	131	99.2	96.9	92.2	84.4	72.8	56.7	35.5	10
20	136	99.2	96.8	91.9	83.9	71.9	55.3	33.4	20
30	140	99.2	96.7	91.7	83.4	71.0	53.9	31.3	30
40	145	99.1	96.5	91.4	82.8	70.1	52.4	29.1	40
50	149	99.1	96.4	91.1	82.3	69.2	51.0	27.0	50
11° 0	100.154	199.1	296.3	390.8	481.8	568.2	649.5	724.8	11° 0
10	158	99.1	96.2	90.6	81.2	67.3	48.0	22.5	10
20	163	99.0	96.1	90.3	80.7	66.3	46.5	20.3	20
30	168	99.0	96.0	90.0	80.1	65.3	44.9	18.0	30
40	173	99.0	95.9	89.7	79.5	64.3	43.3	15.7	40
50	178	98.9	95.7	89.4	78.9	63.3	41.8	13.3	50
12° 0	100.183	198.9	295.6	389.1	478.3	562.3	640.1	710.9	12° 0
10	188	98.9	95.5	88.8	77.7	61.3	38.5	08.5	10
20	193	98.8	95.4	88.5	77.1	60.2	36.9	06.1	20
30	199	98.8	95.3	88.2	76.5	59.2	35.2	03.7	30
40	204	98.8	95.1	87.9	75.9	58.1	33.5	01.2	40
50	209	98.7	95.0	87.6	75.3	57.0	31.8	698.6	50
13° 0	100.215	198.7	294.9	387.2	474.6	555.9	630.1	696.1	13° 0
10	220	98.7	94.7	86.9	74.0	54.8	28.3	93.5	10
20	226	98.6	94.6	86.6	73.3	53.7	26.5	90.9	20
30	232	98.6	94.5	86.3	72.7	52.5	24.8	88.3	30
40	237	98.6	94.3	85.9	72.0	51.4	22.9	85.7	40
50	243	98.5	94.2	85.6	71.3	50.2	21.1	83.0	50
14° 0	100.249	198.5	294.1	385.2	470.6	549.1	619.3	680.3	14° 0
10	255	98.5	93.9	84.9	70.0	47.9	17.4	77.5	10
20	261	98.4	93.8	84.5	69.3	46.7	15.5	74.8	20
30	267	98.4	93.6	84.2	68.6	45.5	13.6	72.0	30
40	274	98.4	93.5	83.8	67.8	44.2	11.7	69.2	40
50	280	98.3	93.3	83.4	67.1	43.0	09.8	66.3	50
15° 0	100.286	198.3	293.2	383.1	466.4	541.7	607.8	663.5	15° 0
10	293	98.3	93.0	82.7	65.7	40.5	05.8	60.6	10
20	299	98.2	92.9	82.3	64.9	39.2	03.8	57.7	20
30	306	98.2	92.7	81.9	64.2	37.9	01.8	54.8	30
40	312	98.1	92.6	81.5	63.4	36.6	599.8	51.8	40
50	319	98.1	92.4	81.2	62.6	35.3	97.8	48.8	50
16° 0	100.326	198.1	292.3	380.8	461.9	534.0	595.7	645.8	16° 0
10	332	98.0	92.1	80.4	61.1	32.6	93.6	42.8	10
20	339	98.0	91.9	80.0	60.3	31.3	91.5	39.7	20
30	346	97.9	91.8	79.6	59.5	29.9	89.4	36.6	30
40	353	97.9	91.6	79.1	58.7	28.6	87.3	33.6	40
50	361	97.8	91.4	78.7	57.9	27.2	85.1	30.4	50
17° 0	100.368	197.8	291.3	378.3	457.1	525.8	582.9	627.3	17° 0
10	375	97.8	91.1	77.9	56.2	24.4	80.7	24.1	10
20	382	97.7	90.9	77.5	55.4	22.9	78.5	20.9	20
30	390	97.7	90.7	77.0	54.6	21.5	76.3	17.7	30
40	397	97.6	90.6	76.6	53.7	20.1	74.1	14.5	40
50	405	97.6	90.4	76.2	52.9	18.6	71.8	11.2	50
18° 0	100.412	197.5	290.2	375.7	452.0	517.2	569.6	608.0	18° 0
10	420	97.5	90.0	75.3	51.1	15.7	67.3	04.7	10
20	428	97.4	89.8	74.8	50.4	14.2	65.0	01.3	20
30	436	97.4	89.7	74.4	49.4	12.7	62.7	598.0	30
40	444	97.4	89.5	73.9	48.5	11.2	60.3	94.7	40
50	452	97.3	89.3	73.5	47.6	09.7	58.0	91.3	50
19° 0	100.460	197.3	289.1	373.0	446.7	508.1	555.6	587.9	19° 0
10	468	97.2	88.9	72.6	45.8	06.6	53.3	84.5	10
20	476	97.2	88.7	72.1	44.9	05.0	50.9	81.0	20
30	484	97.1	88.5	71.6	44.0	03.5	48.5	77.6	30
40	493	97.1	88.3	71.1	43.0	01.9	46.0	74.1	40
50	501	97.0	88.1	70.7	42.1	00.3	43.6	70.6	50
20° 0	100.510	197.0	287.9	370.2	441.1	498.7	541.1	567.1	20° 0

Degree	Actual Arc.	2 Sta.	3 Sta.	4 Sta.	5 Sta.	6 Sta.	7 Sta.	8 Sta.	Degree

Acres	L'gth. Feet.	Acres	L'gth. Feet.	Acres	L'gth. Feet.	Acres	L'gth. Feet.	Ac
0.00		0.60	263.54	1.20	524.90	1.80	786.26	2
.01	2.18	.61	267.89	.21	529.25	.81	790.61	
.02	6.53	.62	272.25	.22	533.61	.82	794.97	
.03	10.89	.63	276.61	.23	537.97	.83	799.33	
.04	15.25	.64	280.96	.24	542.32	.84	803.68	
0.05	19.60	0.65	285.32	1.25	546.68	1.85	808.04	2
.06	23.96	.66	289.67	.26	551.03	.86	812.39	
.07	28.31	.67	294.03	.27	555.39	.87	816.75	
.08	32.67	.68	298.39	.28	559.75	.88	821.11	
.09	37.03	.69	302.74	.29	564.10	.89	825.46	
0.10	41.38	0.70	307.10	1.30	568.46	1.90	829.82	2
.11	45.74	.71	311.45	.31	572.81	.91	834.17	
.12	50.09	.72	315.81	.32	577.17	.92	838.53	
.13	54.45	.73	320.17	.33	581.53	.93	842.89	
.14	58.81	.74	324.52	.34	585.88	.94	847.24	
0.15	63.16	0.75	328.88	1.35	590.24	1.95	851.60	2
.16	67.52	.76	333.23	.36	594.59	.96	855.95	
.17	71.87	.77	337.59	.37	598.95	.97	860.31	
.18	76.23	.78	341.95	.38	603.31	.98	864.67	
.19	80.59	.79	346.30	.39	607.66	.99	869.02	
0.20	84.94	0.80	350.66	1.40	612.02	2.00	873.38	2
.21	89.30	.81	355.01	.41	616.37	.01	877.73	
.22	93.65	.82	359.37	.42	620.73	.02	882.09	
.23	98.01	.83	363.73	.43	625.09	.03	886.45	
.24	102.37	.84	368.08	.44	629.44	.04	890.80	
0.25	106.72	0.85	372.44	1.45	633.80	2.05	895.16	2
.26	111.08	.86	376.79	.46	638.15	.06	899.51	
.27	115.43	.87	381.15	.47	642.51	.07	903.87	
.28	119.79	.88	385.51	.48	646.87	.08	908.23	
.29	124.15	.89	389.86	.49	651.22	.09	912.58	
0.30	128.50	0.90	394.22	1.50	655.58	2.10	916.94	2
.31	132.86	.91	398.57	.51	659.93	.11	921.29	
.32	137.21	.92	402.93	.52	664.29	.12	925.65	
.33	141.57	.93	407.29	.53	668.65	.13	930.01	
.34	145.93	.94	411.64	.54	673.00	.14	934.36	
0.35	150.28	0.95	416.00	1.55	677.36	2.15	938.72	2
.36	154.64	.96	420.35	.56	681.71	.16	943.07	
.37	158.99	.97	424.71	.57	686.07	.17	947.43	
.38	163.35	.98	429.07	.58	690.43	.18	951.79	
.39	167.71	.99	433.42	.59	694.78	.19	956.14	
0.40	172.06	1.00	437.78	1.60	699.14	2.20	960.50	2
.41	176.42	.01	442.13	.61	703.49	.21	964.85	
.42	180.77	.02	446.49	.62	707.85	.22	969.21	
.43	185.13	.03	450.85	.63	712.21	.23	973.57	
.44	189.49	.04	455.10	.64	716.56	.24	977.92	
0.45	193.84	1.05	459.56	1.65	720.92	2.25	982.28	2
.46	198.20	.06	463.91	.66	725.27	.26	986.63	
.47	202.55	.07	468.27	.67	729.63	.27	990.99	
.48	206.91	.08	472.63	.68	733.99	.28	995.35	
.49	211.27	.09	476.98	.69	738.34	.29	999.70	
0.50	215.62	1.10	481.34	1.70	742.70	2.30	1004.06	2
.51	219.98	.11	485.69	.71	747.05	.31	1008.41	
.52	224.33	.12	490.05	.72	751.41	.32	1012.77	
.53	228.69	.13	494.41	.73	755.77	.33	1017.13	
.54	233.05	.14	498.76	.74	760.12	.34	1021.48	
0.55	237.40	1.15	503.12	1.75	764.48	2.35	1025.84	2
.56	241.76	.16	507.47	.76	768.83	.36	1030.19	
.57	246.11	.17	511.83	.77	773.19	.37	1034.55	
.58	250.47	.18	516.19	.78	777.55	.38	1038.91	
.59	254.83	.19	520.54	.79	781.90	.39	1043.26	
0.60	259.18	1.20	524.90	1.80	786.26	2.40	1047.62	
	263.54							

TABLE X.—CURVES FOR METRIC SYSTEM

Radius Meters	Log. Radius.	Tang. Off.	Mid. Ord.	Length Arc 20 m. Chord	Equiv. U. S. Curve	Defl. Angle 20 m. Chord
3437.75	3.536274	.058	.015	20.000	0°30′	0° 10′
1718.88	3.235246	.116	.019	20.000	1 01	20
1145.93	3.059158	.175	.044	20.000	1 31	30
859.46	2.934224	.233	.058	20.000	2 02	40
687.57	2.837319	.291	.073	20.001	2 32	50
572.99	2.758145	.349	.087	20.001	3 03	1°
491.14	2.691206	.407	.102	20.001	3 33	10
429.76	2.633223	.465	.116	20.002	4 04	20
382.02	2.582081	.524	.131	20.002	4 35	30
343.82	2.536335	.582	.145	20.003	5 05	40
312.58	2.494955	.640	.160	20.003	5 36	50
286.54	2.457181	.698	.175	20.004	6 06	2°
264.51	2.422434	.756	.189	20.005	6 36	10
245.62	2.390266	.814	.204	20.006	7 07	20
229.26	2.360320	.872	.218	20.006	7 37	30
214.94	2 332311	.931	.233	20.007	8 08	40
202.30	2.306002	.989	.247	20.008	8 39	50
191.07	2.281200	1.047	.262	20.009	9 09	3°
181.03	2.257741	1.105	.276	20.010	9 40	10
171.98	2.235489	1.163	.291	20.011	10 10	20
163.80	2.214325	1.221	.316	20.012	10 41	30
156.37	2.194148	1.279	.320	20.014	11 11	40
149.58	2.174870	1.337	.335	20.015	11 42	50
143.36	2.156415	1.395	.349	20.016	12 13	4°
137.63	2.138717	1.453	.364	20.018	12 43	10
132.35	2.121715	1.511	.378	20.019	13 14	20
127.45	2.105357	1.569	.393	20.021	13 44	30
122.91	2.089596	1.627	.407	20.022	14 15	40
118.68	2.074391	1.685	.422	20.024	14 46	50
114.74	2.059704	1.743	.437	20.025	15 16	5°
111.05	2.045501	1.801	.451	20.027	15 47	10
107.58	2.031751	1.859	.466	20.029	16 18	20
104.33	2.018427	1.917	.480	20.031	16 48	30
101.28	2.005503	1.975	.495	20 033	17 19	40
98.39	1.992956	2.033	.509	20.035	17 50	50
95.67	1.980765	2.091	.524	20.037	18 20	6°
93.09	1.968911	2.148	.539	20.039	18 51	10
90.65	1.957375	2.206	.553	20.041	19 22	20
88.34	1.946141	2.264	.568	20.043	19 52	30
86.14	1.935194	2.322	.582	20.045	20 23	40
84.05	1.924520	2.380	.597	20.047	20 54	50
82.06	1.914106	2.437	.612	20.050	21 25	7°
80.16	1.903938	2.495	.626	20.052	21 56	10
78.34	1.894008	2.553	.641	20.055	22 27	20
76.61	1.884302	2.602	.655	20.057	22 57	30
74.96	1.874813	2.668	.670	20.060	23 28	40
73.37	1.865530	2.726	.685	20.062	23 59	50
71.85	1.856445	2.783	.699	20.065	24 30	8°
70.40	1.847549	2.841	.714	20.068	25 01	10
69.00	1.838836	2.899	.729	20.071	25 32	20
67.65	1.830298	2.956	.743	20.074	26 03	30
66.36	1.821928	3.014	.758	20.076	26 33	40
65.12	1.813720	3.071	.772	20.079	27 05	50
63.92	1.805668	3.129	.787	20.082	27 36	9°
62.77	1.797766	3.186	.802	20.086	28 07	10
61.66	1.790008	3.244	.816	20.089	28 38	20
60.59	1.782391	3.301	.831	20.092	29 09	30
59.55	1.774908	3.358	.846	20.095	29 40	40
58.55	1.767556	3.416	.860	20.099	30 11	50
57.59	1.760330	3.473	.875	20.102	30 42	10°

TABLE XI.—BAROMETRIC HEIGHTS.

Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Ba me Re ing Inc
31.00	0	30.40	533	29.80	1076	29.20	1630	28
30.99	9	39	542	79	1085	19	1639	
98	18	38	551	78	1094	18	1649	
97	27	37	559	77	1103	17	1658	
96	35	36	569	76	1113	16	1668	
30.95	44	30.35	578	29.75	1122	29.15	1677	28
94	53	34	587	74	1132	14	1687	
93	62	33	596	73	1141	13	1696	
92	71	32	605	72	1150	12	1706	
91	80	31	613	71	1159	11	1715	
30.90	88	30.30	622	29.70	1169	29.10	1725	28
89	97	29	631	69	1177	09	1734	
88	106	28	640	68	1186	08	1743	
87	115	27	649	67	1195	07	1752	
86	124	26	658	66	1205	06	1762	
30.85	133	30.25	667	29.65	1214	29.05	1771	28
84	142	24	676	64	1224	04	1781	
83	151	23	685	63	1233	03	1790	
82	160	22	694	62	1242	02	1799	
81	168	21	703	61	1251	01	1809	
30.80	177	30.20	712	29.60	1260	29.00	1818	28
79	186	19	721	59	1269	28.99	1827	
78	195	18	730	58	1278	98	1837	
77	203	17	740	57	1287	97	1846	
76	212	16	749	56	1296	96	1856	
30.75	221	30.15	758	29.55	1305	28.95	1865	28
74	230	14	767	54	1314	94	1875	
73	239	13	776	53	1324	93	1884	
72	247	12	785	52	1333	92	1894	
71	256	11	794	51	1342	91	1903	
30.70	265	30.10	803	29.50	1352	28.90	1913	28
69	274	09	812	49	1361	89	1922	
68	283	08	821	48	1370	88	1931	
67	292	07	830	47	1379	87	1941	
66	301	06	839	46	1389	86	1950	
30.65	310	30.05	849	29.45	1398	28.85	1960	28
64	318	04	857	44	1408	84	1969	
63	327	03	866	43	1417	83	1979	
62	336	02	875	42	1426	82	1988	
61	345	01	884	41	1435	81	1998	
30.60	354	30.00	893	29.40	1445	28.80	2007	28
59	363	29.99	903	39	1454	79	2016	
58	372	98	911	38	1464	78	2026	
57	381	97	920	37	1473	77	2035	
56	390	96	929	36	1482	76	2044	
30.55	399	29.95	938	29.35	1491	28.75	2054	28
54	407	94	947	34	1500	74	2063	
53	416	93	956	33	1509	73	2073	
52	425	92	965	32	1519	72	2082	
51	434	91	976	31	1528	71	2091	
30.50	443	29.90	985	29.30	1537	28.70	2101	28
49	452	89	994	29	1546	69	2111	
48	461	88	1002	28	1556	68	2120	
47	470	87	1012	27	1565	67	2129	
46	479	86	1021	26	1574	66	2139	
30.45	488	29.85	1030	29.25	1583	28.65	2148	28
44	497	84	1039	24	1593	64	2158	
43	506	83	1049	23	1603	63	2168	
42	515	82	1058	22	1612	62	2177	
41	524	81	1067	21	1621	61	2186	
30.40	533	29.80	1076	29.20	1630	28.60	2196	28

TABLE XI.—BAROMETRIC HEIGHTS.

Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.
2774	27.40	3365	26.80	3968	26.20	4585	25.60	5216
2784	39	3375	79	3978	19	4596	59	5227
2794	38	3384	78	3988	18	4606	58	5237
2804	37	3394	77	3999	17	4617	57	5248
2813	36	3404	76	4009	16	4627	56	5259
2823	27.35	3414	26.75	4019	26.15	4638	25.55	5270
2833	34	3424	74	4030	14	4648	54	5281
2843	33	3434	73	4040	13	4658	53	5291
2853	32	3444	72	4050	12	4669	52	5302
2863	31	3454	71	4060	11	4679	51	5312
2873	27.30	3464	26.70	4070	26.10	4690	25.50	5323
2882	29	3474	69	4081	09	4700	49	5333
2892	28	3484	68	4091	08	4711	48	5344
2901	27	3494	67	4101	07	4721	47	5355
2911	26	3504	66	4111	06	4731	46	5365
2921	27.25	3514	26.65	4122	26.05	4742	25.45	5376
2930	24	3524	64	4132	04	4752	44	5387
2940	23	3534	63	4142	03	4763	43	5397
2950	22	3544	62	4152	02	4773	42	5408
2960	21	3554	61	4163	01	4784	41	5419
2969	27.20	3564	26.60	4173	26.00	4794	25.40	5429
2979	19	3574	59	4183	25.99	4805	39	5440
2989	18	3584	58	4193	98	4815	38	5451
2999	17	3594	57	4203	97	4826	37	5462
3009	16	3604	56	4213	96	4836	36	5473
3019	27.15	3614	26.55	4223	25.95	4847	25.35	5483
3029	14	3624	54	4233	94	4857	34	5494
3039	13	3634	53	4244	93	4868	33	5505
3048	12	3644	52	4254	92	4878	32	5516
3058	11	3654	51	4264	91	4889	31	5527
3068	27.10	3665	26.50	4274	25.90	4899	25.30	5537
3078	09	3675	49	4284	89	4910	29	5548
3087	08	3685	48	4294	88	4920	28	5559
3097	07	3695	47	4304	87	4931	27	5570
3107	06	3705	46	4315	86	4941	26	5581
3117	27.05	3715	26.45	4326	25.85	4952	25.25	5592
3126	04	3725	44	4336	84	4962	24	5602
3136	03	3735	43	4347	83	4973	23	5613
3146	02	3745	42	4357	82	4983	22	5624
3156	01	3755	41	4368	81	4994	21	5635
3166	27.00	3765	26.40	4378	25.80	5004	25.20	5646
3176	26.99	3775	39	4388	79	5014	19	5657
3186	98	3785	38	4399	78	5025	18	5668
3196	97	3795	37	4409	77	5036	17	5679
3206	96	3806	36	4419	76	5046	16	5689
3216	26.95	3816	26.35	4430	25.75	5057	25.15	5700
3225	94	3826	34	4440	74	5067	14	5711
3235	93	3836	33	4450	73	5078	13	5722
3245	92	3846	32	4461	72	5088	12	5733
3255	91	3856	31	4472	71	5099	11	5744
3265	26.90	3866	26.30	4482	25.70	5110	25.10	5754
3275	89	3876	29	4492	69	5121	09	5765
3285	88	3886	28	4502	68	5132	08	5776
3295	87	3897	27	4513	67	5142	07	5787
3305	86	3907	26	4523	66	5153	06	5798
3315	26.85	3917	26.25	4533	25.65	5164	25.05	5809
3325	84	3927	24	4544	64	5174	04	5820
3335	83	3938	23	4554	63	5185	03	5831
3345	82	3948	22	4565	62	5195	02	5842
3355	81	3958	21	4575	61	5206	01	5853
3365	26.80	3968	26.20	4585	25.60	5216	25.00	5863

TABLE XI.—BAROMETRIC HEIGHTS.

Barometer Readings. Inches	Hgts. Feet	Barometer Readings. Inches	Hgts. Feet	Barometer Readings. Inches	Hgts. Feet	Barometer Readings. Inches	Hgts. Feet	Ba me Re in Inc
25.00	5863	24.40	6525	23.80	7203	23.20	7900	22
24.99	5874	39	6536	79	7214	19	7912	
98	5885	38	6547	78	7226	18	7923	
97	5896	37	6559	77	7237	17	7935	
96	5907	36	6570	76	7249	16	7946	
24.95	5918	24.35	6581	23.75	7261	23.15	7958	22
94	5929	34	6592	74	7272	14	7969	
93	5940	33	6603	73	7283	13	7981	
92	5950	32	6615	72	7294	12	7992	
91	5962	31	6626	71	7305	11	8004	
24.90	5972	24.30	6637	23.70	7316	23.10	8015	22
89	5983	29	6648	69	7327	09	8027	
88	5994	28	6659	68	7339	08	8039	
87	6005	27	6671	67	7350	07	8051	
86	6016	26	6682	66	7362	06	8063	
24.85	6027	24.25	6693	23.65	7374	23.05	8075	22
84	6038	24	6705	64	7386	04	8086	
83	6049	23	6716	63	7398	03	8098	
82	6060	22	6727	62	7409	02	8110	
81	6071	21	6738	61	7421	01	8122	
24.80	6082	24.20	6750	23.60	7433	23.00	8134	22
79	6093	19	6761	59	7445	22.99	8146	
78	6104	18	6772	58	7456	98	8158	
77	6115	17	6783	57	7468	97	8170	
76	6126	16	6795	56	7480	96	8182	
24.75	6137	24.15	6806	23.55	7492	22.95	8194	22
74	6148	14	6817	54	7503	94	8206	
73	6159	13	6828	53	7515	93	8218	
72	6170	12	6840	52	7527	92	8230	
71	6181	11	6851	51	7539	91	8242	
24.70	6192	24.10	6862	23.50	7550	22.90	8254	22
69	6203	09	6873	49	7562	89	8266	
68	6214	08	6885	48	7574	88	8278	
67	6225	07	6896	47	7585	87	8290	
66	6236	06	6907	46	7597	86	8302	
24.65	6247	24.05	6919	23.45	7609	22.85	8314	22
64	6258	04	6930	44	7621	84	8326	
63	6269	03	6941	43	7633	83	8338	
62	6280	02	6953	42	7644	82	8350	
61	6291	01	6964	41	7656	81	8362	
24.60	6302	24.00	6976	23.40	7667	22.80	8374	22
59	6313	23.99	6987	39	7679	79	8386	
58	6324	98	6999	38	7690	78	8398	
57	6335	97	7010	37	7702	77	8410	
56	6346	96	7022	36	7713	76	8422	
24.55	6357	23.95	7033	23.35	7725	22.75	8434	22.
54	6368	94	7045	34	7736	74	8446	
53	6379	93	7056	33	7748	73	8458	
52	6390	92	7068	32	7759	72	8470	
51	6401	91	7079	31	7771	71	8482	
24.50	6412	23.90	7090	23.30	7782	22.70	8495	22.
49	6424	89	7101	29	7793	69	8507	
48	6435	88	7113	28	7805	68	8519	
47	6446	87	7124	27	7817	67	8531	
46	6458	86	7135	26	7829	66	8543	
24.45	6469	23.85	7146	23.25	7841	22.65	8555	22.
44	6480	84	7157	24	7853	64	8567	
43	6491	83	7168	23	7865	63	8579	
42	6503	82	7180	22	7876	62	8591	
41	6514	81	7191	21	7888	61	8603	
24.40	6525	23.80	7203	23.20	7900	22.60	8615	22.

TABLE XI.—BAROMETRIC HEIGHTS.

Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.	Barometer Readings. Inches	Hgts. Feet.
22.00	9348	21.40	10101	20.80	10876	20.20	11673
21.99	9360	39	10114	79	10889	19	11687
98	9372	38	10126	78	10902	18	11700
97	9384	37	10139	77	10915	17	11714
96	9397	36	10151	76	10928	16	11727
21.95	9410	21.35	10164	20.75	10941	20.15	11741
94	9422	34	10176	74	10954	14	11754
93	9435	33	10189	73	10967	13	11768
92	9447	32	10202	72	10980	12	11781
91	9460	31	10214	71	10993	11	11795
21.90	9472	21.30	10228	20.70	11006	20.10	11808
89	9485	29	10241	69	11019	09	11821
88	9497	28	10253	68	11032	08	11835
87	9510	27	10266	67	11045	07	11859
86	9522	26	10278	66	11058	06	11863
21.85	9535	21.25	10291	20.65	11071	20.05	11877
84	9547	24	10304	64	11084	04	11891
83	9560	23	10317	63	11097	03	11905
82	9572	22	10330	62	11110	02	11918
81	9585	21	10343	61	11123	01	11932
21.80	9597	21.20	10355	20.60	11136	20.00	11945
79	9610	19	10368	59	11149		
78	9622	18	10381	58	11163		
77	9635	17	10394	57	11176		
76	9647	16	10407	56	11190		
21.75	9660	21.15	10420	20.55	11204		
74	9672	14	10432	54	11217		
73	9685	13	10445	53	11230		
72	9697	12	10458	52	11243		
71	9710	11	10471	51	11257		
21.70	9722	21.10	10484	20.50	11270		
69	9735	09	10497	49	11284		
68	9747	08	10509	48	11297		
67	9760	07	10522	47	11311		
66	9772	06	10535	46	11324		
21.65	9785	21.05	10548	20.45	11338		
64	9797	04	10561	44	11351		
63	9810	03	10574	43	11364		
62	9822	02	10587	42	11377		
61	9835	01	10600	41	11391		
21.60	9848	21.00	10613	20.40	11404		
59	9861	20.99	10627	39	11418		
58	9873	98	10640	38	11431		
57	9886	97	10654	37	11444		
56	9898	96	10667	36	11457		
21.55	9911	20.95	10681	20.35	11470		
54	9923	94	10694	34	11483		
53	9936	93	10707	33	11496		
52	9949	92	10720	32	11509		
51	9962	91	10733	31	11523		
21.50	9974	20.90	10746	20.30	11536		
49	9987	89	10759	29	11550		
48	9999	88	10772	28	11563		
47	10012	87	10785	27	11577		
46	10025	86	10798	26	11591		
21.45	10038	20.85	10811	20.25	11605		
44	10050	84	10824	24	11618		
43	10063	83	10837	23	11632		
42	10075	82	10850	22	11645		
41	10088	81	10863	21	11659		
21.40	10101	20.80	10876	20.20	11673		

N.	0	1	2	3	4	5	6	7	8
100	000000	0434	0868	1301	1734	2166	2598	3029	3
101	4321	4751	5181	5609	6038	6466	6894	7321	7
102	8600	9026	9451	9876	*0300	*0724	*1147	*1570	*1
103	012837	3259	3680	4100	4521	4940	5360	5779	6
104	7033	7451	7868	8284	8700	9116	9532	9947	*0
105	021189	1603	2016	2428	2841	3252	3664	4075	4
106	5306	5715	6125	6533	6942	7350	7757	8164	8
107	9384	9789	*0195	*0600	*1004	*1408	*1812	*2216	*2
108	033424	3826	4227	4628	5029	5430	5830	6230	6
109	7426	7825	8223	8620	9017	9414	9811	*0207	*0

N.	Diff.	1	2	3	4	5	6	7	8
PROPORTIONAL PARTS	434	43	87	130	174	217	260	304	
	433	43	87	130	173	217	260	303	
	432	43	86	130	173	216	259	302	
	431	43	86	129	172	216	259	302	
	430	43	86	129	172	215	258	301	
	429	43	86	129	172	215	257	300	
	428	43	86	128	171	214	257	300	
	427	43	85	128	171	214	256	299	
	426	43	85	128	170	213	256	298	
	425	43	85	128	170	213	255	298	
	424	42	85	127	170	212	254	297	
	423	42	85	127	169	212	254	296	
	422	42	84	127	169	211	253	295	
	421	42	84	126	168	211	253	295	
	420	42	84	126	168	210	252	294	
	419	42	84	126	168	210	251	293	
	418	42	84	125	167	209	251	293	
	417	42	83	125	167	209	250	292	
	416	42	83	125	166	208	250	291	
	415	42	83	125	166	208	249	291	
	414	41	83	124	166	207	248	290	
	413	41	83	124	165	207	248	289	
	412	41	82	124	165	206	247	288	
	411	41	82	123	164	206	247	288	
	410	41	82	123	164	205	246	287	
	409	41	82	123	164	205	245	286	
	408	41	82	122	163	204	245	286	
	407	41	81	122	163	204	244	285	
	406	41	81	122	162	203	244	284	
	405	41	81	122	162	203	243	284	
	404	40	81	121	162	202	242	283	
	403	40	81	121	161	202	242	282	
	402	40	80	121	161	201	241	281	
	401	40	80	120	160	201	241	281	
	400	40	80	120	160	200	240	280	
	399	40	80	120	160	200	239	279	
	398	40	80	119	159	199	239	279	
	397	40	79	119	159	199	238	278	
	396	40	79	119	158	198	238	277	
	395	40	79	119	158	198	237	277	
	394	39	79	118	158	197	236	276	
	393	39	79	118	157	197	236	275	
	392	39	78	118	157	196	235	274	
	391	39	78	117	156	196	235	274	
	390	39	78	117	156	195	234	273	
	389	39	78	117	156	195	233	272	
	388	39	78	116	155	194	233	272	
	Diff.	1	2	3	4	5	6	7	8

N.	0	1	2	3	4	5	6	7	8	9	Diff.
110	041393	1787	2182	2576	2969	3362	3755	4148	4540	4932	393
111	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	390
112	9218	9606	9993	*0380	*0766	*1153	*1538	*1924	*2309	*2694	386
113	053078	3463	3846	4230	4613	4996	5378	5760	6142	6524	383
114	6905	7286	7666	8046	8426	8805	9185	9563	9942	*0320	379
115	060698	1075	1452	1829	2206	2582	2958	3333	3709	4083	376
116	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	373
117	8186	8557	8928	9298	9668	*0038	*0407	*0776	*1145	*1514	370
118	071882	2250	2617	2985	3352	3718	4085	4451	4816	5182	366
119	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	9543	9904	*0266	*0626	*0987	*1347	*1707	*2067	*2426	360
121	082785	3144	3503	3861	4219	4576	4934	5291	5647	6004	357
122	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
123	9905	*0258	*0611	*0963	*1315	*1667	*2018	*2370	*2721	*3071	352
124	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349

N.	Diff.	1	2	3	4	5	6	7	8	9	Diff.
PROPORTIONAL PARTS	387	39	77	116	155	194	232	271	310	348	387
	386	39	77	116	154	193	232	270	309	347	386
	385	39	77	116	154	193	231	270	308	347	385
	384	38	77	115	154	192	230	269	307	346	384
	383	38	77	115	153	192	230	268	306	345	383
	382	38	76	115	153	191	229	267	306	344	382
	381	38	76	114	152	191	229	267	305	343	381
	380	38	76	114	152	190	228	266	304	342	380
	379	38	76	114	152	190	227	265	303	341	379
	378	38	76	113	151	189	227	265	302	340	378
	377	38	75	113	151	189	226	264	302	339	377
	376	38	75	113	150	188	226	263	301	338	376
	375	38	75	113	150	188	225	263	300	338	375
	374	37	75	112	150	187	224	262	299	337	374
	373	37	75	112	149	187	224	261	298	336	373
	372	37	74	112	149	186	223	260	298	335	372
	371	37	74	111	148	186	223	260	297	334	371
	370	37	74	111	148	185	222	259	296	333	370
	369	37	74	111	148	185	221	258	295	332	369
	368	37	74	110	147	184	221	258	294	331	368
	367	37	73	110	147	184	220	257	294	330	367
	366	37	73	110	146	183	220	256	293	329	366
	365	37	73	110	146	183	219	256	292	329	365
	364	36	73	109	146	182	218	255	291	328	364
	363	36	73	109	145	182	218	254	290	327	363
	362	36	72	109	145	181	217	253	290	326	362
	361	36	72	108	144	181	217	253	289	325	361
	360	36	72	108	144	180	216	252	288	324	360
	359	36	72	108	144	180	215	251	287	323	359
	358	36	72	107	143	179	215	251	286	322	358
	357	36	71	107	143	179	214	250	286	321	357
	356	36	71	107	142	178	214	249	285	320	356
	355	36	71	107	142	178	213	249	284	320	355
	354	35	71	106	142	177	212	248	283	319	354
	353	35	71	106	141	177	212	247	282	318	353
	352	35	70	106	141	176	211	246	282	317	352
	351	35	70	105	140	176	211	246	281	316	351
	350	35	70	105	140	175	210	245	280	315	350
	349	35	70	105	140	175	209	244	279	314	349
	348	35	70	104	139	174	209	244	278	313	348
	347	35	69	104	139	174	208	243	278	312	347
	Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
125	096910	7257	7604	7951	8298	8644	8990	9335	968
126	100371	0715	1059	1403	1747	2091	2434	2777	311
127	3804	4146	4487	4828	5169	5510	5851	6191	653
128	7210	7549	7888	8227	8565	8903	9241	9579	991
129	110590	0926	1263	1599	1934	2270	2605	2940	327
130	113943	4277	4611	4944	5278	5611	5943	6276	660
131	7271	7603	7934	8265	8595	8926	9256	9586	991
132	120574	0903	1231	1560	1888	2216	2544	2871	319
133	3852	4178	4504	4830	5156	5481	5806	6131	645
134	7105	7429	7753	8076	8399	8722	9045	9368	969
135	130334	0655	0977	1298	1619	1939	2260	2580	290
136	3539	3858	4177	4496	4814	5133	5451	5769	608
137	6721	7037	7354	7671	7987	8303	8618	8934	924
138	9879	*0194	*0508	*0822	*1136	*1450	*1763	*2076	*238
139	143015	3327	3639	3951	4263	4574	4885	5196	550

N.	Diff.	1	2	3	4	5	6	7	8
PROPORTIONAL PARTS	347	35	69	104	139	174	208	243	27
	346	35	69	104	138	173	208	242	27
	345	35	69	104	138	173	207	242	27
	344	34	69	103	138	172	206	241	27
	343	34	69	103	137	172	206	240	27
	342	34	68	103	137	171	205	239	27
	341	34	68	102	136	171	205	239	27
	340	34	68	102	136	170	204	238	27
	339	34	68	102	136	170	203	237	27
	338	34	68	101	135	169	203	237	27
	337	34	67	101	135	169	202	236	27
	336	34	67	101	134	168	202	235	26
	335	34	67	101	134	168	201	235	26
	334	33	67	100	134	167	200	234	26
	333	33	67	100	133	167	200	233	26
	332	33	66	100	133	166	199	232	26
	331	33	66	99	132	166	199	232	26
	330	33	66	99	132	165	198	231	26
	329	33	66	99	132	165	197	230	26
	328	33	66	98	131	164	197	230	26
	327	33	65	98	131	164	196	229	26
	326	33	65	98	130	163	196	228	26
	325	33	65	98	130	163	195	228	26
	324	32	65	97	130	162	194	227	25
	323	32	65	97	129	162	194	226	25
	322	32	64	97	129	161	193	225	25
	321	32	64	96	128	161	193	225	25
	320	32	64	96	128	160	192	224	25
	319	32	64	96	128	160	191	223	25
	318	32	64	95	127	159	191	223	25
	317	32	63	95	127	159	190	222	25
	316	32	63	95	126	158	190	221	25
	315	32	63	95	126	158	189	221	25
	314	31	63	94	126	157	188	220	25
	313	31	63	94	125	157	188	219	25
	312	31	62	94	125	156	187	218	25
	311	31	62	93	124	156	187	218	24
	310	31	62	93	124	155	186	217	24
	309	31	62	93	124	155	185	216	24
	308	31	62	92	123	154	185	216	24
	307	31	61	92	123	154	184	215	24
	Diff	1	2	3	4	5	6	7	8

	0	1	2	3	4	5	6	7	8	9	Diff.
0	146128	6438	6748	7058	7367	7676	7985	8294	8603	8911	309
1	9219	9527	9835	*0142	*0449	*0756	*1063	*1370	*1676	*1982	307
2	152288	2594	2900	3205	3510	3815	4120	4424	4728	5032	305
3	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	303
4	8362	8664	8965	9266	9567	9868	*0168	*0469	*0769	*1068	301
5	161368	1667	1967	2266	2564	2863	3161	3460	3758	4055	299
6	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	297
7	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
8	170262	0555	0848	1141	1434	1726	2019	2311	2603	2895	293
9	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
0	176091	6381	6670	6959	7248	7536	7825	8113	8401	8689	289
1	8977	9264	9552	9839	*0126	*0413	*0699	*0986	*1272	*1558	287
2	181844	2129	2415	2700	2985	3270	3555	3839	4123	4407	285
3	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
4	7521	7803	8084	8366	8647	8928	9209	9490	9771	*0051	281
5	190332	0612	0892	1171	1451	1730	2010	2289	2567	2846	279
6	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
7	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
8	8657	8932	9206	9481	9755	*0029	*0303	*0577	*0850	*1124	274
9	201397	1670	1943	2216	2488	2761	3033	3305	3577	3848	272

Diff.	1	2	3	4	5	6	7	8	9	Diff.
306	31	61	92	122	153	184	214	245	275	306
305	31	61	92	122	153	183	214	244	275	305
304	30	61	91	122	152	182	213	243	274	304
303	30	61	91	121	152	182	212	242	273	303
302	30	60	91	121	151	181	211	242	272	302
301	30	60	90	120	151	181	211	241	271	301
300	30	60	90	120	150	180	210	240	270	300
299	30	60	90	120	150	179	209	239	269	299
298	30	60	89	119	149	179	209	238	268	298
297	30	59	89	119	149	178	208	238	267	297
296	30	59	89	118	148	178	207	237	266	296
295	30	59	89	118	148	177	207	236	266	295
294	29	59	88	118	147	176	206	235	265	294
293	29	59	88	117	147	176	205	234	264	293
292	29	58	88	117	146	175	204	234	263	292
291	29	58	87	116	146	175	204	233	262	291
290	29	58	87	116	145	174	203	232	261	290
289	29	58	87	116	145	173	202	231	260	289
288	29	58	86	115	144	173	202	230	259	288
287	29	57	86	115	144	172	201	230	258	287
286	29	57	86	114	143	172	200	229	257	286
285	29	57	86	114	143	171	200	228	257	285
284	28	57	85	114	142	170	199	227	256	284
283	28	57	85	113	142	170	198	226	255	283
282	28	56	85	113	141	169	197	226	254	282
281	28	56	84	112	141	169	197	225	253	281
280	28	56	84	112	140	168	196	224	252	280
279	28	56	84	112	140	167	195	223	251	279
278	28	56	83	111	139	167	195	222	250	278
277	28	55	83	111	139	166	194	222	249	277
276	28	55	83	110	138	166	193	221	248	276
275	28	55	83	110	138	165	193	220	248	275
274	27	55	82	110	137	164	192	219	247	274
273	27	55	82	109	137	164	191	218	246	273
272	27	54	82	109	136	163	190	218	245	272
271	27	54	81	108	136	163	190	217	244	271

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
160	204120	4391	4663	4934	5204	5475	5746	6016	6286
161	6826	7096	7365	7634	7904	8173	8441	8710	8979
162	9515	9783	*0051	*0319	*0586	*0853	*1121	*1388	*1654
163	212188	2454	2720	2986	3252	3518	3783	4049	4314
164	4844	5109	5373	5638	5902	6166	6430	6694	6957
165	217484	7747	8010	8273	8536	8798	9060	9323	9585
166	220108	0370	0631	0892	1153	1414	1675	1936	2196
167	2716	2976	3236	3496	3755	4015	4274	4533	4792
168	5309	5568	5826	6084	6342	6600	6858	7115	7372
169	7887	8144	8400	8657	8913	9170	9426	9682	9938
170	230449	0704	0960	1215	1470	1724	1979	2234	2488
171	2996	3250	3504	3757	4011	4264	4517	4770	5023
172	5528	5781	6033	6285	6537	6789	7041	7292	7544
173	8046	8297	8548	8799	9049	9299	9550	9800	*0050
174	240549	0799	1048	1297	1546	1795	2044	2293	2541
175	243038	3286	3534	3782	4030	4277	4525	4772	5019
176	5513	5759	6006	6252	6499	6745	6991	7237	7482
177	7973	8219	8464	8709	8954	9198	9443	9687	9932
178	250420	0664	0908	1151	1395	1638	1881	2125	2368
179	2853	3096	3338	3580	3822	4064	4306	4548	4790

N.	Diff.	1	2	3	4	5	6	7	8
PROPORTIONAL PARTS	272	27	54	82	109	136	163	190	218
	271	27	54	81	108	136	163	190	217
	270	27	54	81	108	135	162	189	216
	269	27	54	81	108	135	161	188	215
	268	27	54	80	107	134	161	188	214
	267	27	53	80	107	134	160	187	214
	266	27	53	80	106	133	160	186	213
	265	27	53	80	106	133	159	186	212
	264	26	53	79	106	132	158	185	211
	263	26	53	79	105	132	158	184	210
	262	26	52	79	105	131	157	183	210
	261	26	52	78	104	131	157	183	209
	260	26	52	78	104	130	156	182	208
	259	26	52	78	104	130	155	181	207
	258	26	52	77	103	129	155	181	206
	257	26	51	77	103	129	154	180	206
	256	26	51	77	102	128	154	179	205
	255	26	51	77	102	128	153	179	204
	254	25	51	76	102	127	152	178	203
	253	25	51	76	101	127	152	177	202
	252	25	50	76	101	126	151	176	202
	251	25	50	75	100	126	151	176	201
	250	25	50	75	100	125	150	175	200
	249	25	50	75	100	125	149	174	199
	248	25	50	74	99	124	149	174	198
	247	25	49	74	99	124	148	173	198
	246	25	49	74	98	123	148	172	197
	245	25	49	74	98	123	147	172	196
	244	24	49	73	98	122	146	171	195
	243	24	49	73	97	122	146	170	194
	242	24	48	73	97	121	145	169	194
	308	24	48	72	96	121	145	169	193
	307	24	48	72	96	120	144	168	192
	Diff	1	2	3	4	5	6	7	8

0	1	2	3	4	5	6	7	8	9	Diff.
255273	5514	5755	5996	6237	6477	6718	6958	7198	7439	241
7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	239
260071	0310	0548	0787	1025	1263	1501	1739	1976	2214	238
2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
267172	7406	7641	7875	8110	8344	8578	8812	9046	9279	234
9513	9746	9980	*0213	*0446	*0679	*0912	*1144	*1377	*1609	233
271842	2074	2306	2538	2770	3001	3233	3464	3696	3927	232
4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	230
6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	229
278754	8982	9211	9439	9667	9895	*0123	*0351	*0578	*0806	228
281033	1261	1488	1715	1942	2169	2396	2622	2849	3075	227
3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	226
5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	225
7802	8026	8249	8473	8696	8920	9143	9366	9589	9812	223
290035	0257	0480	0702	0925	1147	1369	1591	1813	2034	222
2256	2478	2699	2920	3141	3363	3584	3804	4025	4246	221
4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	220
6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	219
8853	9071	9289	9507	9725	9943	*0161	*0378	*0595	*0813	218
301030	1247	1464	1681	1898	2114	2331	2547	2764	2980	217
3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	216
5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	215
7496	7710	7924	8137	8351	8564	8778	8991	9204	9417	213
9630	9843	*0056	*0268	*0481	*0693	*0906	*1118	*1330	*1542	212

Diff.	1	2	3	4	5	6	7	8	9	Diff.
239	24	48	72	96	120	143	167	191	215	239
238	24	48	71	95	119	143	167	190	214	238
237	24	47	71	95	119	142	166	190	213	237
236	24	47	71	94	118	142	165	189	212	236
235	24	47	71	94	118	141	165	188	212	235
234	23	47	70	94	117	140	164	187	211	234
233	23	47	70	93	117	140	163	186	210	233
232	23	46	70	93	116	139	162	186	209	232
231	23	46	69	92	116	139	162	185	208	231
230	23	46	69	92	115	138	161	184	207	230
229	23	46	69	92	115	137	160	183	206	229
228	23	46	68	91	114	137	160	182	205	228
227	23	45	68	91	114	136	159	182	204	227
226	23	45	68	90	113	136	158	181	203	226
225	23	45	68	90	113	135	158	180	203	225
224	22	45	67	90	112	134	157	179	202	224
223	22	45	67	89	112	134	156	178	201	223
222	22	44	67	89	111	133	155	178	200	222
221	22	44	66	88	111	133	155	177	199	221
220	22	44	66	88	110	132	154	176	198	220
219	22	44	66	88	110	131	153	175	197	219
218	22	44	65	87	109	131	153	174	196	218
217	22	43	65	87	109	130	152	174	195	217
216	22	43	65	86	108	130	151	173	194	216
215	22	43	65	86	108	129	151	172	194	215
214	21	43	64	86	107	128	150	171	193	214
213	21	43	64	85	107	128	149	170	192	213
212	21	42	64	85	106	127	148	170	191	212

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8	
205	311754	1966	2177	2389	2600	2812	3023	3234	3445	3
206	3867	4078	4289	4499	4710	4920	5130	5340	5551	5
207	5970	6180	6390	6599	6809	7018	7227	7436	7646	7
208	8063	8272	8481	8689	8898	9106	9314	9522	9730	9
209	320146	0354	0562	0769	0977	1184	1391	1598	1805	2
210	322219	2426	2633	2839	3046	3252	3458	3665	3871	4
211	4282	4488	4694	4899	5105	5310	5516	5721	5926	6
212	6336	6541	6745	6950	7155	7359	7563	7767	7972	8
213	8380	8583	8787	8991	9194	9398	9601	9805	*0008	*0
214	330414	0617	0819	1022	1225	1427	1630	1832	2034	2
215	332438	2640	2842	3044	3246	3447	3649	3850	4051	4
216	4454	4655	4856	5057	5257	5458	5658	5859	6059	6
217	6460	6660	6860	7060	7260	7459	7659	7858	8058	8
218	8456	8656	8855	9054	9253	9451	9650	9849	*0047	*0
219	340444	0642	0841	1039	1237	1435	1632	1830	2028	2
220	342423	2620	2817	3014	3212	3409	3606	3802	3999	4
221	4392	4589	4785	4981	5178	5374	5570	5766	5962	6
222	6353	6549	6744	6939	7135	7330	7525	7720	7915	8
223	8305	8500	8694	8889	9083	9278	9472	9666	9860	*0
224	350248	0442	0636	0829	1023	1216	1410	1603	1796	1
225	352183	2375	2568	2761	2954	3147	3339	3532	3724	3
226	4108	4301	4493	4685	4876	5068	5260	5452	5643	5
227	6026	6217	6408	6599	6790	6981	7172	7363	7554	7
228	7935	8125	8316	8506	8696	8886	9076	9266	9456	9
229	9835	*0025	*0215	*0404	*0593	*0783	*0972	*1161	*1350	*1
230	361728	1917	2105	2294	2482	2671	2859	3048	3236	3
231	3612	3800	3988	4176	4363	4551	4739	4926	5113	5
232	5488	5675	5862	6049	6236	6423	6610	6796	6983	7
233	7356	7542	7729	7915	8101	8287	8473	8659	8845	9
234	9216	9401	9587	9772	9958	*0143	*0328	*0513	*0698	*0

N.	Diff.	1	2	3	4	5	6	7	8	
PROPORTIONAL PARTS	212	21	42	64	85	106	127	148	170	
	211	21	42	63	84	106	127	148	169	
	210	21	42	63	84	105	126	147	168	
	209	21	42	63	84	105	125	146	167	
	208	21	42	62	83	104	125	146	166	
	207	21	41	62	83	104	124	145	166	
	206	21	41	62	82	103	124	144	165	
	205	21	41	62	82	103	123	144	164	
	204	20	41	61	82	102	122	143	163	
	203	20	41	61	81	102	122	142	162	
	202	20	40	61	81	101	121	141	162	
	201	20	40	60	80	101	121	141	161	
	200	20	40	60	80	100	120	140	160	
	199	20	40	60	80	100	119	139	159	
	198	20	40	59	79	99	119	139	158	
	197	20	39	59	79	99	118	138	158	
	196	20	39	59	78	98	118	137	157	
	195	20	39	59	78	98	117	137	156	
	194	19	39	58	78	97	116	136	155	
	193	19	39	58	77	97	116	135	154	
	192	19	38	58	77	96	115	134	154	
	191	19	38	57	76	96	115	134	153	
	190	19	38	57	76	95	114	133	152	
	189	19	38	57	76	95	113	132	151	
	188	19	38	56	75	94	113	132	150	
	Diff.	1	2	3	4	5	6	7	8	

N.	0	1	2	3	4	5	6	7	8	9	Diff.
235	371068	1253	1437	1622	1806	1991	2175	2360	2544	2728	184
236	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
237	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
238	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
239	8398	8580	8761	8943	9124	9306	9487	9668	9849	*0030	181
240	380211	0392	0573	0754	0934	1115	1296	1476	1656	1837	181
241	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
242	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
243	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
244	7390	7568	7746	7923	8101	8279	8456	8634	8811	8989	178
245	389166	9343	9520	9698	9875	*0051	*0228	*0405	*0582	*0759	177
246	390935	1112	1288	1464	1641	1817	1993	2169	2345	2521	176
247	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	176
248	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
249	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
250	397940	8114	8287	8461	8634	8808	8981	9154	9328	9501	173
251	9674	9847	*0020	*0192	*0365	*0538	*0711	*0883	*1056	*1228	173
252	401401	1573	1745	1917	2089	2261	2433	2605	2777	2949	172
253	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	171
254	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
255	406540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
256	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
257	9933	*0102	*0271	*0440	*0609	*0777	*0946	*1114	*1283	*1451	169
258	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
259	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	5140	5307	5474	5641	5808	5974	6141	6308	6474	167
261	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
262	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
263	9956	*0121	*0286	*0451	*0616	*0781	*0945	*1110	*1275	*1439	165
264	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	164

N.	Diff.	1	2	3	4	5	6	7	8	9	Diff.
PROPORTIONAL PARTS	187	19	37	56	75	94	112	131	150	168	187
	186	19	37	56	74	93	112	130	149	167	186
	185	19	37	56	74	93	111	130	148	167	185
	184	18	37	55	74	92	110	129	147	166	184
	183	18	37	55	73	92	110	128	146	165	183
	182	18	36	55	73	91	109	127	146	164	182
	181	18	36	54	72	91	109	127	145	163	181
	180	18	36	54	72	90	108	126	144	162	180
	179	18	36	54	72	90	107	125	143	161	179
	178	18	36	53	71	89	107	125	142	160	178
	177	18	35	53	71	89	106	124	142	159	177
	176	18	35	53	70	88	106	123	141	158	176
	175	18	35	53	70	88	105	123	140	158	175
	174	17	35	52	70	87	104	122	139	157	174
	173	17	35	52	69	87	104	121	138	156	173
	172	17	34	52	69	86	103	120	138	155	172
	171	17	34	51	68	86	103	120	137	154	171
	170	17	34	51	68	85	102	119	136	153	170
	169	17	34	51	68	85	101	118	135	152	169
	168	17	34	50	67	84	101	118	134	151	168
	167	17	33	50	67	84	100	117	134	150	167
	166	17	33	50	66	83	100	116	133	149	166
	165	17	33	50	66	83	99	116	132	149	165
	164	16	33	49	66	82	98	115	131	148	164

	Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8	
265	423246	3410	3574	3737	3901	4065	4228	4392	4555	
266	4882	5045	5208	5371	5534	5697	5860	6023	6186	
267	6511	6674	6836	6999	7161	7324	7486	7648	7811	
268	8135	8297	8459	8621	8783	8944	9106	9268	9429	
269	9752	9914	*0075	*0236	*0398	*0559	*0720	*0881	*1042	*
270	431364	1525	1685	1846	2007	2167	2328	2488	2649	
271	2969	3130	3290	3450	3610	3770	3930	4090	4249	
272	4569	4729	4888	5048	5207	5367	5526	5685	5844	
273	6163	6322	6481	6640	6799	6957	7116	7275	7433	
274	7751	7909	8067	8226	8384	8542	8701	8859	9017	
275	439333	9491	9648	9806	9964	*0122	*0279	*0437	*0594	*
276	440909	1066	1224	1381	1538	1695	1852	2009	2166	
277	2480	2637	2793	2950	3106	3263	3419	3576	3732	
278	4045	4201	4357	4513	4669	4825	4981	5137	5293	
279	5604	5760	5915	6071	6226	6382	6537	6692	6848	
280	447158	7313	7468	7623	7778	7933	8088	8242	8397	
281	8706	8861	9015	9170	9324	9478	9633	9787	9941	*
282	450249	0403	0557	0711	0865	1018	1172	1326	1479	
283	1786	1940	2093	2247	2400	2553	2706	2859	3012	
284	3318	3471	3624	3777	3930	4082	4235	4387	4540	
285	454845	4997	5150	5302	5454	5606	5758	5910	6062	
286	6366	6518	6670	6821	6973	7125	7276	7428	7579	
287	7882	8033	8184	8336	8487	8638	8789	8940	9091	
288	9392	9543	9694	9845	9995	*0146	*0296	*0447	*0597	*
289	460898	1048	1198	1348	1499	1649	1799	1948	2098	
290	462398	2548	2697	2847	2997	3146	3296	3445	3594	
291	3893	4042	4191	4340	4490	4639	4788	4936	5085	
292	5383	5532	5680	5829	5977	6126	6274	6423	6571	
293	6868	7016	7164	7312	7460	7608	7756	7904	8052	
294	8347	8495	8643	8790	8938	9085	9233	9380	9527	
295	469822	9969	*0116	*0263	*0410	*0557	*0704	*0851	*0998	*
296	471292	1438	1585	1732	1878	2025	2171	2318	2464	
297	2756	2903	3049	3195	3341	3487	3633	3779	3925	
298	4216	4362	4508	4653	4799	4944	5090	5235	5381	
299	5671	5816	5962	6107	6252	6397	6542	6687	6832	

N.	Diff.	1	2	3	4	5	6	7	8
PROPORTIONAL PARTS	164	16	33	49	66	82	98	115	131
	163	16	33	49	65	82	98	114	130
	162	16	32	49	65	81	97	113	130
	161	16	32	48	64	81	97	113	129
	160	16	32	48	64	80	96	112	128
	159	16	32	48	64	80	95	111	127
	158	16	32	47	63	79	95	111	126
	157	16	31	47	63	79	94	110	126
	156	16	31	47	62	78	94	109	125
	155	16	31	47	62	78	93	109	124
	154	15	31	46	62	77	92	108	123
	153	15	31	46	61	77	92	107	122
	152	15	30	46	61	76	91	106	122
	151	15	30	45	60	76	91	106	121
	150	15	30	45	60	75	90	105	120
	149	15	30	45	60	75	89	104	119
	148	15	30	44	59	74	89	104	118
	147	15	29	44	59	74	88	103	118
	146	15	29	44	58	73	88	102	117
	145	15	29	44	58	73	87	102	116
	144	14	29	43	58	72	86	101	115
	143	14	29	43	57	72	86	100	114
	Diff.	1	2	3	4	5	6	7	8

0	1	2	3	4	5	6	7	8	9	Diff.
477121	7266	7411	7555	7700	7844	7989	8133	8278	8422	145
8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
480007	0151	0294	0438	0582	0725	0869	1012	1156	1299	144
1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	143
484300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	142
7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
9958	*0099	*0239	*0380	*0520	*0661	*0801	*0941	*1081	*1222	140
491362	1502	1642	1782	1922	2062	2201	2341	2481	2621	140
2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	139
6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
498311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
9687	9824	9962	*0099	*0236	*0374	*0511	*0648	*0785	*0922	137
501059	1196	1333	1470	1607	1744	1880	2017	2154	2291	137
2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	136
3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
505150	5286	5421	5557	5693	5828	5964	6099	6234	6370	136
6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	135
7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	135
9203	9337	9471	9606	9740	9874	*0009	*0143	*0277	*0411	134
510545	0679	0813	0947	1081	1215	1349	1482	1616	1750	134
511883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	133
4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	132
7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	132
518514	8646	8777	8909	9040	9171	9303	9434	9566	9697	131
9828	9959	*0090	*0221	*0353	*0484	*0615	*0745	*0876	*1007	131
521138	1269	1400	1530	1661	1792	1922	2053	2183	2314	131
2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
525045	5174	5304	5434	5563	5693	5822	5951	6081	6210	129
6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	129
8917	9045	9174	9302	9430	9559	9687	9815	9943	*0072	128
530200	0328	0456	0584	0712	0840	0968	1096	1223	1351	128

Diff.	1	2	3	4	5	6	7	8	9	Diff.
142	14	28	43	57	71	85	99	114	128	142
141	14	28	42	56	71	85	99	113	127	141
140	14	28	42	56	70	84	98	112	126	140
139	14	28	42	56	70	83	97	111	125	139
138	14	28	41	55	69	83	97	110	124	138
137	14	27	41	55	69	82	96	110	123	137
136	14	27	41	54	68	82	95	109	122	136
135	14	27	41	54	68	81	95	108	122	135
134	13	27	40	54	67	80	94	107	121	134
133	13	27	40	53	67	80	93	106	120	133
132	13	26	40	53	66	79	92	106	119	132
131	13	26	39	52	66	79	92	105	118	131
130	13	26	39	52	65	78	91	104	117	130
129	13	26	39	52	65	77	90	103	116	129
128	13	26	38	51	64	77	90	102	115	128
127	13	25	38	51	64	76	89	102	114	127

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
340	531479	1607	1734	1862	1990	2117	2245	2372	2500
341	2754	2882	3009	3136	3264	3391	3518	3645	3772
342	4026	4153	4280	4407	4534	4661	4787	4914	5041
343	5294	5421	5547	5674	5800	5927	6053	6180	6306
344	6558	6685	6811	6937	7063	7189	7315	7441	7567
345	537819	7945	8071	8197	8322	8448	8574	8699	8825
346	9076	9202	9327	9452	9578	9703	9829	9954	*0079
347	540329	0455	0580	0705	0830	0955	1080	1205	1330
348	1579	1704	1829	1953	2078	2203	2327	2452	2576
349	2825	2950	3074	3199	3323	3447	3571	3696	3820
350	544068	4192	4316	4440	4564	4688	4812	4936	5060
351	5307	5431	5555	5678	5802	5925	6049	6172	6296
352	6543	6666	6789	6913	7036	7159	7282	7405	7529
353	7775	7898	8021	8144	8267	8389	8512	8635	8758
354	9003	9126	9249	9371	9494	9616	9739	9861	9984
355	550228	0351	0473	0595	0717	0840	0962	1084	1206
356	1450	1572	1694	1816	1938	2060	2181	2303	2425
357	2668	2790	2911	3033	3155	3276	3398	3519	3640
358	3883	4004	4126	4247	4368	4489	4610	4731	4852
359	5094	5215	5336	5457	5578	5699	5820	5940	6061
360	556303	6423	6544	6664	6785	6905	7026	7146	7267
361	7507	7627	7748	7868	7988	8108	8228	8349	8469
362	8709	8829	8948	9068	9188	9308	9428	9548	9667
363	9907	*0026	*0146	*0265	*0385	*0504	*0624	*0743	*0863
364	561101	1221	1340	1459	1578	1698	1817	1936	2055
365	562293	2412	2531	2650	2769	2887	3006	3125	3244
366	3481	3600	3718	3837	3955	4074	4192	4311	4429
367	4666	4784	4903	5021	5139	5257	5376	5494	5612
368	5848	5966	6084	6202	6320	6437	6555	6673	6791
369	7026	7144	7262	7379	7497	7614	7732	7849	7967
370	568202	8319	8436	8554	8671	8788	8905	9023	9140
371	9374	9491	9608	9725	9842	9959	*0076	*0193	*0309
372	570543	0660	0776	0893	1010	1126	1243	1359	1476
373	1709	1825	1942	2058	2174	2291	2407	2523	2639
374	2872	2988	3104	3220	3336	3452	3568	3684	3800
375	574031	4147	4263	4379	4494	4610	4726	4841	4957
376	5188	5303	5419	5534	5650	5765	5880	5996	6111
377	6341	6457	6572	6687	6802	6917	7032	7147	7262
378	7492	7607	7722	7836	7951	8066	8181	8295	8410
379	8639	8754	8868	8983	9097	9212	9326	9441	9555

N.	Diff.	1	2	3	4	5	6	7	8
PROP. PARTS	128	13	26	38	51	64	77	90	102
	127	13	25	38	51	64	76	89	102
	126	13	25	38	50	63	76	88	101
	125	13	25	38	50	63	75	88	100
	124	12	25	37	50	62	74	87	99
	123	12	25	37	49	62	74	86	98
	122	12	24	37	49	61	73	85	98
	121	12	24	36	48	61	73	85	97
	120	12	24	36	48	60	72	84	96
	119	12	24	36	48	60	71	83	95
	118	12	24	35	47	59	71	83	94
	117	12	23	35	47	59	70	82	94
	116	12	23	35	46	58	70	81	93
	Diff.	1	2	3	4	5	6	7	8

L.	0	1	2	3	4	5	6	7	8	9	Diff.
0	579784	9898	*0012	*0126	*0241	*0355	*0469	*0583	*0697	*0811	114
1	580925	1039	1153	1267	1381	1495	1608	1722	1836	1950	114
2	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	114
3	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
4	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	113
5	585461	5574	5686	5799	5912	6024	6137	6250	6362	6475	113
	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	112
	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	112
	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	112
	9950	*0061	*0173	*0284	*0396	*0507	*0619	*0730	*0842	*0953	112
	591065	1176	1287	1399	1510	1621	1732	1843	1955	2066	111
	2177	2288	2399	2510	2621	2732	2843	2954	3064	3175	111
	3286	3397	3508	3618	3729	3840	3950	4061	4171	4282	111
	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	110
	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	110
	596597	6707	6817	6927	7037	7146	7256	7366	7476	7586	110
	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	109
	9883	9992	*0101	*0210	*0319	*0428	*0537	*0646	*0755	*0864	109
	600973	1082	1191	1299	1408	1517	1625	1734	1843	1951	109
	602060	2169	2277	2386	2494	2603	2711	2819	2928	3036	108
	3144	3253	3361	3469	3577	3686	3794	3902	4010	4118	108
	4226	4334	4442	4550	4658	4766	4874	4982	5089	5197	108
	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	108
	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	107
	607455	7562	7669	7777	7884	7991	8098	8205	8312	8419	107
	8526	8633	8740	8847	8954	9061	9167	9274	9381	9488	107
	9594	9701	9808	9914	*0021	*0128	*0234	*0341	*0447	*0554	107
	610660	0767	0873	0979	1086	1192	1298	1405	1511	1617	106
	1723	1829	1936	2042	2148	2254	2360	2466	2572	2678	106
	612784	2890	2996	3102	3207	3313	3419	3525	3630	3736	106
	3842	3947	4053	4159	4264	4370	4475	4581	4686	4792	106
	4897	5003	5108	5213	5319	5424	5529	5634	5740	5845	105
	5950	6055	6160	6265	6370	6476	6581	6686	6790	6895	105
	7000	7105	7210	7315	7420	7525	7629	7734	7839	7943	105
	618048	8153	8257	8362	8466	8571	8676	8780	8884	8989	105
	9093	9198	9302	9406	9511	9615	9719	9824	9928	*0032	104
	620136	0240	0344	0448	0552	0656	0760	0864	0968	1072	104
	1176	1280	1384	1488	1592	1695	1799	1903	2007	2110	104
	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	104

Diff.	1	2	3	4	5	6	7	8	9	Diff.
115	12	23	35	46	58	69	81	92	104	115
114	11	23	34	46	57	68	80	91	103	114
113	11	23	34	45	57	68	79	90	102	113
112	11	22	34	45	56	67	78	90	101	112
111	11	22	33	44	56	67	78	89	100	111
110	11	22	33	44	55	66	77	88	99	110
109	11	22	33	44	55	65	76	87	98	109
108	11	22	32	43	54	65	76	86	97	108
107	11	21	32	43	54	64	75	86	96	107
106	11	21	32	42	53	64	74	85	95	106
105	11	21	32	42	53	63	74	84	95	105
104	10	21	31	42	52	62	73	83	94	104
103	10	21	31	41	52	62	72	82	93	103

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
510	707570	7655	7740	7826	7911	7996	8081	8166	8251
511	8421	8506	8591	8676	8761	8846	8931	9015	9100
512	9270	9355	9440	9524	9609	9694	9779	9863	9948
513	710117	0202	0287	0371	0456	0540	0625	0710	0794
514	0963	1048	1132	1217	1301	1385	1470	1554	1639
515	711807	1892	1976	2060	2144	2229	2313	2397	2481
516	2650	2734	2818	2902	2986	3070	3154	3238	3323
517	3491	3575	3659	3742	3826	3910	3994	4078	4162
518	4330	4414	4497	4581	4665	4749	4833	4916	5000
519	5167	5251	5335	5418	5502	5586	5669	5753	5836
520	716003	6087	6170	6254	6337	6421	6504	6588	6671
521	6838	6921	7004	7088	7171	7254	7338	7421	7504
522	7671	7754	7837	7920	8003	8086	8169	8253	8336
523	8502	8585	8668	8751	8834	8917	9000	9083	9165
524	9331	9414	9497	9580	9663	9745	9828	9911	9994
525	720159	0242	0325	0407	0490	0573	0655	0738	0821
526	0986	1068	1151	1233	1316	1398	1481	1563	1646
527	1811	1893	1975	2058	2140	2222	2305	2387	2469
528	2634	2716	2798	2881	2963	3045	3127	3209	3291
529	3456	3538	3620	3702	3784	3866	3948	4030	4112
530	724276	4358	4440	4522	4604	4685	4767	4849	4931
531	5095	5176	5258	5340	5422	5503	5585	5667	5748
532	5912	5993	6075	6156	6238	6320	6401	6483	6564
533	6727	6809	6890	6972	7053	7134	7216	7297	7379
534	7541	7623	7704	7785	7866	7948	8029	8110	8191
535	728354	8435	8516	8597	8678	8759	8841	8922	9003
536	9165	9246	9327	9408	9489	9570	9651	9732	9813
537	9974	*0055	*0136	*0217	*0298	*0378	*0459	*0540	*0621
538	730782	0863	0944	1024	1105	1186	1266	1347	1428
539	1589	1669	1750	1830	1911	1991	2072	2152	2233
540	732394	2474	2555	2635	2715	2796	2876	2956	3037
541	3197	3278	3358	3438	3518	3598	3679	3759	3839
542	3999	4079	4160	4240	4320	4400	4480	4560	4640
543	4800	4880	4960	5040	5120	5200	5279	5359	5439
544	5599	5679	5759	5838	5918	5998	6078	6157	6237
545	736397	6476	6556	6635	6715	6795	6874	6954	7034
546	7193	7272	7352	7431	7511	7590	7670	7749	7829
547	7987	8067	8146	8225	8305	8384	8463	8543	8622
548	8781	8860	8939	9018	9097	9177	9256	9335	9414
549	9572	9651	9731	9810	9889	9968	*0047	*0126	*0205
550	740363	0442	0521	0600	0678	0757	0836	0915	0994
551	1152	1230	1309	1388	1467	1546	1624	1703	1782
552	1939	2018	2096	2175	2254	2332	2411	2489	2568
553	2725	2804	2882	2961	3039	3118	3196	3275	3353
554	3510	3588	3667	3745	3823	3902	3980	4058	4136

N.	Diff.	1	2	3	4	5	6	7	8
PROP. PARTS	86	9	17	26	34	43	52	60	69
	85	9	17	26	34	43	51	60	68
	84	8	17	25	34	42	50	59	67
	83	8	17	25	33	42	50	58	66
	82	8	16	25	33	41	49	57	66
	81	8	16	24	32	41	49	57	65
	80	8	16	24	32	40	48	56	64
	79	8	16	24	32	40	47	55	63
	Diff.	1	2	3	4	5	6	7	8

0	1	2	3	4	5	6	7	8	9	Diff.
667453	7546	7640	7733	7826	7920	8013	8106	8199	8293	93
8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	93
9317	9410	9503	9596	9689	9782	9875	9967	*0060	*0153	93
670246	0339	0431	0524	0617	0710	0802	0895	0988	1080	93
1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	93
672098	2190	2283	2375	2467	2560	2652	2744	2836	2929	92
3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	92
3942	4034	4126	4218	4310	4402	4494	4586	4677	4769	92
4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	92
5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	92
676694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
8518	8609	8700	8791	8882	8973	9064	9155	9246	9337	91
9428	9519	9610	9700	9791	9882	9973	*0063	*0154	*0245	91
680336	0426	0517	0607	0698	0789	0879	0970	1060	1151	91
681241	1332	1422	1513	1603	1693	1784	1874	1964	2055	90
2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	90
3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	90
4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	90
685742	5831	5921	6010	6100	6189	6279	6368	6458	6547	89
6636	6726	6815	6904	6994	7083	7172	7261	7351	7440	89
7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
8420	8509	8598	8687	8776	8865	8953	9042	9131	9220	89
9309	9398	9486	9575	9664	9753	9841	9930	*0019	*0107	89
690196	0285	0373	0462	0550	0639	0728	0816	0905	0993	89
1081	1170	1258	1347	1435	1524	1612	1700	1789	1877	88
1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	88
2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	88
3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	88
694605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	87
6356	6444	6531	6618	6706	6793	6880	6968	7055	7142	87
7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	87
8101	8188	8275	8362	8449	8535	8622	8709	8796	8883	87
698970	9057	9144	9231	9317	9404	9491	9578	9664	9751	87
9838	9924	*0011	*0098	*0184	*0271	*0358	*0444	*0531	*0617	87
700704	0790	0877	0963	1050	1136	1222	1309	1395	1482	86
1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	86
2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
703291	3377	3463	3549	3635	3721	3807	3893	3979	4065	86
4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	86
5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	86
5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	85
6718	6803	6888	6974	7059	7144	7229	7315	7400	7485	85

Diff.	1	2	3	4	5	6	7	8	9	Diff.
94	9	19	28	38	47	56	66	75	85	94
93	9	19	28	37	47	56	65	74	84	93
92	9	18	28	37	46	55	64	74	83	92
91	9	18	27	36	46	55	64	73	82	91
90	9	18	27	36	45	54	63	72	81	90
89	9	18	27	36	45	53	62	71	80	89
88	9	18	26	35	44	53	62	70	79	88
87	9	17	26	35	44	52	61	70	78	87
86	9	17	26	34	43	52	60	69	77	86
85	9	17	26	34	43	51	60	68	77	85

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8	9
510	707570	7655	7740	7826	7911	7996	8081	8166	8251	83
511	8421	8506	8591	8676	8761	8846	8931	9015	9100	91
512	9270	9355	9440	9524	9609	9694	9779	9863	9948	*00
513	710117	0202	0287	0371	0456	0540	0625	0710	0794	08
514	0963	1048	1132	1217	1301	1385	1470	1554	1639	17
515	711807	1892	1976	2060	2144	2229	2313	2397	2481	25
516	2650	2734	2818	2902	2986	3070	3154	3238	3323	34
517	3491	3575	3659	3742	3826	3910	3994	4078	4162	42
518	4330	4414	4497	4581	4665	4749	4833	4916	5000	50
519	5167	5251	5335	5418	5502	5586	5669	5753	5836	59
520	716003	6087	6170	6254	6337	6421	6504	6588	6671	67
521	6838	6921	7004	7088	7171	7254	7338	7421	7504	75
522	7671	7754	7837	7920	8003	8086	8169	8253	8336	84
523	8502	8585	8668	8751	8834	8917	9000	9083	9165	92
524	9331	9414	9497	9580	9663	9745	9828	9911	9994	*00
525	720159	0242	0325	0407	0490*	0573	0655	0738	0821	09
526	0986	1068	1151	1233	1316	1398	1481	1563	1646	17
527	1811	1893	1975	2058	2140	2222	2305	2387	2469	25
528	2634	2716	2798	2881	2963	3045	3127	3209	3291	33
529	3456	3538	3620	3702	3784	3866	3948	4030	4112	41
530	724276	4358	4440	4522	4604	4685	4767	4849	4931	50
531	5095	5176	5258	5340	5422	5503	5585	5667	5748	58
532	5912	5993	6075	6156	6238	6320	6401	6483	6564	66
533	6727	6809	6890	6972	7053	7134	7216	7297	7379	74
534	7541	7623	7704	7785	7866	7948	8029	8110	8191	82
535	728354	8435	8516	8597	8678	8759	8841	8922	9003	90
536	9165	9246	9327	9408	9489	9570	9651	9732	9813	98
537	9974	*0055	*0136	*0217	*0298	*0378	*0459	*0540	*0621	*07
538	730782	0863	0944	1024	1105	1186	1266	1347	1428	15
539	1589	1669	1750	1830	1911	1991	2072	2152	2233	23
540	732394	2474	2555	2635	2715	2796	2876	2956	3037	31
541	3197	3278	3358	3438	3518	3598	3679	3759	3839	39
542	3999	4079	4160	4240	4320	4400	4480	4560	4640	47
543	4800	4880	4960	5040	5120	5200	5279	5359	5439	55
544	5599	5679	5759	5838	5918	5998	6078	6157	6237	63
545	736397	6476	6556	6635	6715	6795	6874	6954	7034	71
546	7193	7272	7352	7431	7511	7590	7670	7749	7829	79
547	7987	8067	8146	8225	8305	8384	8463	8543	8622	87
548	8781	8860	8939	9018	9097	9177	9256	9335	9414	94
549	9572	9651	9731	9810	9889	9968	*0047	*0126	*0205	*02
550	740363	0442	0521	0600	0678	0757	0836	0915	0994	10
551	1152	1230	1309	1388	1467	1546	1624	1703	1782	18
552	1939	2018	2096	2175	2254	2332	2411	2489	2568	26
553	2725	2804	2882	2961	3039	3118	3196	3275	3353	34
554	3510	3588	3667	3745	3823	3902	3980	4058	4136	41

N.	Diff.	1	2	3	4	5	6	7	8	
PROP. PARTS	86	9	17	26	34	43	52	60	69	
	85	9	17	26	34	43	51	60	68	
	84	8	17	25	34	42	50	59	67	
	83	8	17	25	33	42	50	58	66	
	82	8	16	25	33	41	49	57	66	
	81	8	16	24	32	41	49	57	65	
	80	8	16	24	32	40	48	56	64	
	79	8	16	24	32	40	47	55	63	
	Diff.	1	2	3	4	5	6	7	8	

	0	1	2	3	4	5	6	7	8	9	Diff.
	744293	4371	4449	4528	4606	4684	4762	4840	4919	4997	78
	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	78
	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	78
	748188	8266	8343	8421	8498	8576	8653	8731	8808	8885	77
	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659	77
	9736	9814	9891	9968	*0045	*0123	*0200	*0277	*0354	*0431	77
	750508	0586	0663	0740	0817	0894	0971	1048	1125	1202	77
	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972	77
	752048	2125	2202	2279	2356	2433	2509	2586	2663	2740	77
	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	77
	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	77
	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	76
	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799	76
	755875	5951	6027	6103	6180	6256	6332	6408	6484	6560	76
	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	76
	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	76
	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	76
	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592	76
	759668	9743	9819	9894	9970	*0045	*0121	*0196	*0272	*0347	75
	760422	0498	0573	0649	0724	0799	0875	0950	1025	1101	75
	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	75
	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	75
	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	75
	763428	3503	3578	3653	3727	3802	3877	3952	4027	4101	75
	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	75
	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	75
	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	74
	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	74
	767156	7230	7304	7379	7453	7527	7601	7675	7749	7823	74
	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	74
	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	74
	9377	9451	9525	9599	9673	9746	9820	9894	9968	*0042	74
	770115	0189	0263	0336	0410	0484	0557	0631	0705	0778	74
	770852	0926	0999	1073	1146	1220	1293	1367	1440	1514	74
	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	73
	774517	4590	4663	4736	4809	4882	4955	5028	5100	5173	73
	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	73
	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	73
	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72

	Diff.	1	2	3	4	5	6	7	8	9	Diff.
	78	8	16	23	31	39	47	55	62	70	78
	77	8	15	23	31	39	46	54	62	69	77
	76	8	15	23	30	38	46	53	61	68	76
	75	8	15	23	30	38	45	53	60	68	75
	74	7	15	22	30	37	44	52	59	67	74
	73	7	15	22	29	37	44	51	58	66	73
	72	7	14	22	29	36	43	50	58	65	72

	Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
600	778151	8224	8296	8368	8441	8513	8585	8658	8730
601	8874	8947	9019	9091	9163	9236	9308	9380	9452
602	9596	9669	9741	9813	9885	9957	*0029	*0101	*0173
603	780317	0389	0461	0533	0605	0677	0749	0821	0893
604	1037	1109	1181	1253	1324	1396	1468	1540	1612
605	781755	1827	1899	1971	2042	2114	2186	2258	2329
606	2473	2544	2616	2688	2759	2831	2902	2974	3046
607	3189	3260	3332	3403	3475	3546	3618	3689	3761
608	3904	3975	4046	4118	4189	4261	4332	4403	4475
609	4617	4689	4760	4831	4902	4974	5045	5116	5187
610	785330	5401	5472	5543	5615	5686	5757	5828	5899
611	6041	6112	6183	6254	6325	6396	6467	6538	6609
612	6751	6822	6893	6964	7035	7106	7177	7248	7319
613	7460	7531	7602	7673	7744	7815	7885	7956	8027
614	8168	8239	8310	8381	8451	8522	8593	8663	8734
615	788875	8946	9016	9087	9157	9228	9299	9369	9440
616	9581	9651	9722	9792	9863	9933	*0004	*0074	*0144
617	790285	0356	0426	0496	0567	0637	0707	0778	0848
618	0988	1059	1129	1199	1269	1340	1410	1480	1550
619	1691	1761	1831	1901	1971	2041	2111	2181	2252
620	792392	2462	2532	2602	2672	2742	2812	2882	2952
621	3092	3162	3231	3301	3371	3441	3511	3581	3651
622	3790	3860	3930	4000	4070	4139	4209	4279	4349
623	4488	4558	4627	4697	4767	4836	4906	4976	5045
624	5185	5254	5324	5393	5463	5532	5602	5672	5741
625	795880	5949	6019	6088	6158	6227	6297	6366	6436
626	6574	6644	6713	6782	6852	6921	6990	7060	7129
627	7268	7337	7406	7475	7545	7614	7683	7752	7821
628	7960	8029	8098	8167	8236	8305	8374	8443	8513
629	8651	8720	8789	8858	8927	8996	9065	9134	9203
630	799341	9409	9478	9547	9616	9685	9754	9823	9892
631	800029	0098	0167	0236	0305	0373	0442	0511	0580
632	0717	0786	0854	0923	0992	1061	1129	1198	1266
633	1404	1472	1541	1609	1678	1747	1815	1884	1952
634	2089	2158	2226	2295	2363	2432	2500	2568	2637
635	802774	2842	2910	2979	3047	3116	3184	3252	3321
636	3457	3525	3594	3662	3730	3798	3867	3935	4003
637	4139	4208	4276	4344	4412	4480	4548	4616	4685
638	4821	4889	4957	5025	5093	5161	5229	5297	5365
639	5501	5569	5637	5705	5773	5841	5908	5976	6044
640	806180	6248	6316	6384	6451	6519	6587	6655	6723
641	6858	6926	6994	7061	7129	7197	7264	7332	7400
642	7535	7603	7670	7738	7806	7873	7941	8008	8076
643	8211	8279	8346	8414	8481	8549	8616	8684	8751
644	8886	8953	9021	9088	9156	9223	9290	9358	9425
645	809560	9627	9694	9762	9829	9896	9964	*0031	*0098
646	810233	0300	0367	0434	0501	0569	0636	0703	0770
647	0904	0971	1039	1106	1173	1240	1307	1374	1441
648	1575	1642	1709	1776	1843	1910	1977	2044	2111
649	2245	2312	2379	2445	2512	2579	2646	2713	2780

N.	Diff.	1	2	3	4	5	6	7	8
PRO. P'TS	73	7	15	22	29	37	44	51	58
	72	7	14	22	29	36	43	50	58
	71	7	14	21	28	36	43	50	57
	70	7	14	21	28	35	42	49	56
	69	7	14	21	28	35	41	48	55
	68	7	14	20	27	34	41	48	54

	Diff.	1	2	3	4	5	6	7	8

0	1	2	3	4	5	6	7	8	9	Diff.
875061	5119	5177	5235	5293	5351	5409	5466	5524	5582	58
5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
877947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
9669	9726	9784	9841	9898	9956	*0013	*0070	*0127	*0185	57
880242	0299	0356	0413	0471	0528	0585	0642	0699	0756	57
880814	0871	0928	0985	1042	1099	1156	1213	1271	1328	57
1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
883661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
886491	6547	6604	6660	6716	6773	6829	6885	6942	6998	56
7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
889302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
9862	9918	9974	*0030	*0086	*0141	*0197	*0253	*0309	*0365	56
890421	0477	0533	0589	0645	0700	0756	0812	0868	0924	56
0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
892095	2150	2206	2262	2317	2373	2429	2484	2540	2595	56
2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
894870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
897627	7682	7737	7792	7847	7902	7957	8012	8067	8122	55
8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
9821	9875	9930	9985	*0039	*0094	*0149	*0203	*0258	*0312	55
900367	0422	0476	0531	0586	0640	0695	0749	0804	0859	55
0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54

Diff.	1	2	3	4	5	6	7	8	9	Diff.
57	6	11	17	23	29	34	40	46	51	57
56	6	11	17	22	28	34	39	45	50	56
55	6	11	17	22	28	33	39	44	50	55
54	5	11	16	22	27	32	38	43	49	54

Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8
700	845098	5160	5222	5284	5346	5408	5470	5532	5594
701	5718	5780	5842	5904	5966	6028	6090	6151	6213
702	6337	6399	6461	6523	6585	6646	6708	6770	6832
703	6955	7017	7079	7141	7202	7264	7326	7388	7449
704	7573	7634	7696	7758	7819	7881	7943	8004	8066
705	848189	8251	8312	8374	8435	8497	8559	8620	8682
706	8805	8866	8928	8989	9051	9112	9174	9235	9297
707	9419	9481	9542	9604	9665	9726	9788	9849	9911
708	850033	0095	0156	0217	0279	0340	0401	0462	0524
709	0646	0707	0769	0830	0891	0952	1014	1075	1136
710	851258	1320	1381	1442	1503	1564	1625	1686	1747
711	1870	1931	1992	2053	2114	2175	2236	2297	2358
712	2480	2541	2602	2663	2724	2785	2846	2907	2968
713	3090	3150	3211	3272	3333	3394	3455	3516	3577
714	3698	3759	3820	3881	3941	4002	4063	4124	4185
715	854306	4367	4428	4488	4549	4610	4670	4731	4792
716	4913	4974	5034	5095	5156	5216	5277	5337	5398
717	5519	5580	5640	5701	5761	5822	5882	5943	6003
718	6124	6185	6245	6306	6366	6427	6487	6548	6608
719	6729	6789	6850	6910	6970	7031	7091	7152	7212
720	857332	7393	7453	7513	7574	7634	7694	7755	7815
721	7935	7995	8056	8116	8176	8236	8297	8357	8417
722	8537	8597	8657	8718	8778	8838	8898	8958	9018
723	9138	9198	9258	9318	9379	9439	9499	9559	9619
724	9739	9799	9859	9918	9978	*0038	*0098	*0158	*0218
725	860338	0398	0458	0518	0578	0637	0697	0757	0817
726	0937	0996	1056	1116	1176	1236	1295	1355	1415
727	1534	1594	1654	1714	1773	1833	1893	1952	2012
728	2131	2191	2251	2310	2370	2430	2489	2549	2608
729	2728	2787	2847	2906	2966	3025	3085	3144	3204
730	863323	3382	3442	3501	3561	3620	3680	3739	3799
731	3917	3977	4036	4096	4155	4214	4274	4333	4392
732	4511	4570	4630	4689	4748	4808	4867	4926	4985
733	5104	5163	5222	5282	5341	5400	5459	5519	5578
734	5696	5755	5814	5874	5933	5992	6051	6110	6169
735	866287	6346	6405	6465	6524	6583	6642	6701	6760
736	6878	6937	6996	7055	7114	7173	7232	7291	7350
737	7467	7526	7585	7644	7703	7762	7821	7880	7939
738	8056	8115	8174	8233	8292	8350	8409	8468	8527
739	8644	8703	8762	8821	8879	8938	8997	9056	9114
740	869232	9290	9349	9408	9466	9525	9584	9642	9701
741	9818	9877	9935	9994	*0053	*0111	*0170	*0228	*0287
742	870404	0462	0521	0579	0638	0696	0755	0813	0872
743	0989	1047	1106	1164	1223	1281	1339	1398	1456
744	1573	1631	1690	1748	1806	1865	1923	1981	2040
745	872156	2215	2273	2331	2389	2448	2506	2564	2622
746	2739	2797	2855	2913	2972	3030	3088	3146	3204
747	3321	3379	3437	3495	3553	3611	3669	3727	3785
748	3902	3960	4018	4076	4134	4192	4250	4308	4366
749	4482	4540	4598	4656	4714	4772	4830	4888	4945

N.	Diff.	1	2	3	4	5	6	7	8
PRO. P'TS	62	6	12	19	25	31	37	43	50
	61	6	12	18	24	31	37	43	49
	60	6	12	18	24	30	36	42	48
	59	6	12	18	24	30	35	41	47
	58	6	12	17	23	29	35	41	46
	Diff.	1	2	3	4	5	6	7	8

N.	0	1	2	3	4	5	6	7	8	9	Diff.
750	875061	5119	5177	5235	5293	5351	5409	5466	5524	5582	58
751	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
752	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
753	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
754	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
755	877947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
756	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
757	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
758	9669	9726	9784	9841	9898	9956	*0013	*0070	*0127	*0185	57
759	880242	0299	0356	0413	0471	0528	0585	0642	0699	0756	57
760	880814	0871	0928	0985	1042	1099	1156	1213	1271	1328	57
761	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
762	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
763	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
764	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
765	883661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
766	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
767	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
768	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
769	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	886491	6547	6604	6660	6716	6773	6829	6885	6942	6998	56
771	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
772	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
773	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
774	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
775	889302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
776	9862	9918	9974	*0030	*0086	*0141	*0197	*0253	*0309	*0365	56
777	890421	0477	0533	0589	0645	0700	0756	0812	0868	0924	56
778	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
779	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
780	892095	2150	2206	2262	2317	2373	2429	2484	2540	2595	56
781	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
782	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
783	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
784	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
785	894870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
786	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
787	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
788	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
789	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	897627	7682	7737	7792	7847	7902	7957	8012	8067	8122	55
791	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
792	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
793	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
794	9821	9875	9930	9985	*0039	*0094	*0149	*0203	*0258	*0312	55
795	900367	0422	0476	0531	0586	0640	0695	0749	0804	0859	55
796	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
797	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
798	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
799	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54

N.	Diff.	1	2	3	4	5	6	7	8	9	Diff.
PR. PTS.	57	6	11	17	23	29	34	40	46	51	57
	56	6	11	17	22	28	34	39	45	50	56
	55	6	11	17	22	28	33	39	44	50	55
	54	5	11	16	22	27	32	38	43	49	54
	Diff.	1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8	9	Diff.
800	903090	3144	3199	3253	3307	3361	3416	3470	3524	3578	54
801	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	54
802	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
803	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	54
804	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	54
805	905796	5850	5904	5958	6012	6066	6119	6173	6227	6281	54
806	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	54
807	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	54
808	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	54
809	7949	8002	8056	8110	8163	8217	8270	8324	8378	8431	54
810	908485	8539	8592	8646	8699	8753	8807	8860	8914	8967	54
811	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
812	9556	9610	9663	9716	9770	9823	9877	9930	9984	*0037	53
813	910091	0144	0197	0251	0304	0358	0411	0464	0518	0571	53
814	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
815	911158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
816	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
817	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
818	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
819	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
820	913814	3867	3920	3973	4026	4079	4132	4184	4237	4290	53
821	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
822	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
823	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
824	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
825	916454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
826	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
827	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	53
828	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	53
829	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	53
830	919078	9130	9183	9235	9287	9340	9392	9444	9496	9549	52
831	9601	9653	9706	9758	9810	9862	9914	9967	*0019	*0071	52
832	920123	0176	0228	0280	0332	0384	0436	0489	0541	0593	52
833	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
834	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
835	921686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
836	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
837	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
838	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
839	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	4331	4383	4434	4486	4538	4589	4641	4693	4744	52
841	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
842	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	52
843	5828	5879	5931	5982	6034	6085	6137	6188	6240	6291	52
844	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	52
845	926857	6908	6959	7011	7062	7114	7165	7216	7268	7319	52
846	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	52
847	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	52
848	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	52
849	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	52

N.	Diff.	1	2	3	4	5	6	7	8	9	Diff.
PR. PTS.	55	6	11	17	22	28	33	39	44	50	55
	54	5	11	16	22	27	32	38	43	49	54
	53	5	11	16	21	27	32	37	42	48	53
	52	5	10	16	21	26	31	36	42	47	52

	Diff.	1	2	3	4	5	6	7	8	9	Diff.

1	2	3	4	5	6	7	8	9	Diff.
9470	9521	9572	9623	9674	9725	9776	9827	9879	51
9981	*0032	*0083	*0134	*0185	*0236	*0287	*0338	*0389	51
0491	0542	0592	0643	0694	0745	0796	0847	0898	51
1000	1051	1102	1153	1204	1254	1305	1356	1407	51
1509	1560	1610	1661	1712	1763	1814	1865	1915	51
2017	2068	2118	2169	2220	2271	2322	2372	2423	51
2524	2575	2626	2677	2727	2778	2829	2879	2930	51
3031	3082	3133	3183	3234	3285	3335	3386	3437	51
3538	3589	3639	3690	3740	3791	3841	3892	3943	51
4044	4094	4145	4195	4246	4296	4347	4397	4448	51
4549	4599	4650	4700	4751	4801	4852	4902	4953	50
5054	5104	5154	5205	5255	5306	5356	5406	5457	50
5558	5608	5658	5709	5759	5809	5860	5910	5960	50
6061	6111	6162	6212	6262	6313	6363	6413	6463	50
6564	6614	6665	6715	6765	6815	6865	6916	6966	50
7066	7117	7167	7217	7267	7317	7367	7418	7468	50
7568	7618	7668	7718	7769	7819	7869	7919	7969	50
8069	8119	8169	8219	8269	8320	8370	8420	8470	50
8570	8620	8670	8720	8770	8820	8870	8920	8970	50
9070	9120	9170	9220	9270	9320	9369	9419	9469	50
9569	9619	9669	9719	9769	9819	9869	9918	9968	50
0068	0118	0168	0218	0267	0317	0367	0417	0467	50
0566	0616	0666	0716	0765	0815	0865	0915	0964	50
1064	1114	1163	1213	1263	1313	1362	1412	1462	50
1561	1611	1660	1710	1760	1809	1859	1909	1958	50
2058	2107	2157	2207	2256	2306	2355	2405	2455	50
2554	2603	2653	2702	2752	2801	2851	2901	2950	50
3049	3099	3148	3198	3247	3297	3346	3396	3445	49
3544	3593	3643	3692	3742	3791	3841	3890	3939	49
4038	4088	4137	4186	4236	4285	4335	4384	4433	49
4532	4581	4631	4680	4729	4779	4828	4877	4927	49
5025	5074	5124	5173	5222	5272	5321	5370	5419	49
5518	5567	5616	5665	5715	5764	5813	5862	5912	49
6010	6059	6108	6157	6207	6256	6305	6354	6403	49
6501	6551	6600	6649	6698	6747	6796	6845	6894	49
6992	7041	7090	7140	7189	7238	7287	7336	7385	49
7483	7532	7581	7630	7679	7728	7777	7826	7875	49
7973	8022	8070	8119	8168	8217	8266	8315	8364	49
8462	8511	8560	8609	8657	8706	8755	8804	8853	49
8951	8999	9048	9097	9146	9195	9244	9292	9341	49
9439	9488	9536	9585	9634	9683	9731	9780	9829	49
9926	9975	*0024	*0073	*0121	*0170	*0219	*0267	*0316	49
0414	0462	0511	0560	0608	0657	0706	0754	0803	49
0900	0949	0997	1046	1095	1143	1192	1240	1289	49
1386	1435	1483	1532	1580	1629	1677	1726	1775	49
1872	1920	1969	2017	2066	2114	2163	2211	2260	48
2356	2405	2453	2502	2550	2599	2647	2696	2744	48
2841	2889	2938	2986	3034	3083	3131	3180	3228	48
3325	3373	3421	3470	3518	3566	3615	3663	3711	48
3808	3856	3905	3953	4001	4049	4098	4146	4194	48

1	2	3	4	5	6	7	8	9	Diff.
5	10	15	20	26	31	36	41	45	51
5	10	15	20	25	30	35	40	45	50
5	10	15	20	25	29	34	39	44	49
5	10	14	19	24	29	34	38	43	48

1	2	3	4	5	6	7	8	9	Diff.

N.	0	1	2	3	4	5	6	7	8	9
1000	000000	0043	0087	0130	0174	0217	0260	0304	0347	0391
1001	0434	0477	0521	0564	0608	0651	0694	0738	0781	0824
1002	0868	0911	0954	0998	1041	1084	1128	1171	1214	1258
1003	1301	1344	1388	1431	1474	1517	1561	1604	1647	1690
1004	1734	1777	1820	1863	1907	1950	1993	2036	2080	2123
1005	002166	2209	2252	2296	2339	2382	2425	2468	2512	2555
1006	2598	2641	2684	2727	2771	2814	2857	2900	2943	2986
1007	3029	3073	3116	3159	3202	3245	3288	3331	3374	3417
1008	3461	3504	3547	3590	3633	3676	3719	3762	3805	3848
1009	3891	3934	3977	4020	4063	4106	4149	4192	4235	4278
1010	004321	4364	4407	4450	4493	4536	4579	4622	4665	4708
1011	4751	4794	4837	4880	4923	4966	5009	5052	5095	5138
1012	5181	5223	5266	5309	5352	5395	5438	5481	5524	5567
1013	5609	5652	5695	5738	5781	5824	5867	5909	5952	5995
1014	6038	6081	6124	6166	6209	6252	6295	6338	6380	6423
1015	006466	6509	6552	6594	6637	6680	6723	6765	6808	6851
1016	6894	6936	6979	7022	7065	7107	7150	7193	7236	7278
1017	7321	7364	7406	7449	7492	7534	7577	7620	7662	7705
1018	7748	7790	7833	7876	7918	7961	8004	8046	8089	8132
1019	8174	8217	8259	8302	8345	8387	8430	8472	8515	8558
1020	008600	8643	8685	8728	8770	8813	8856	8898	8941	8983
1021	9026	9068	9111	9153	9196	9238	9281	9323	9366	9408
1022	9451	9493	9536	9578	9621	9663	9706	9748	9791	9833
1023	9876	9918	9961	*0003	*0045	*0088	*0130	*0173	*0215	*0258
1024	010300	0342	0385	0427	0470	0512	0554	0597	0639	0681
1025	010724	0766	0809	0851	0893	0936	0978	1020	1063	1105
1026	1147	1190	1232	1274	1317	1359	1401	1444	1486	1528
1027	1570	1613	1655	1697	1740	1782	1824	1866	1909	1951
1028	1993	2035	2078	2120	2162	2204	2247	2289	2331	2373
1029	2415	2458	2500	2542	2584	2626	2669	2711	2753	2795
1030	012837	2879	2922	2964	3006	3048	3090	3132	3174	3217
1031	3259	3301	3343	3385	3427	3469	3511	3553	3596	3638
1032	3680	3722	3764	3806	3848	3890	3932	3974	4016	4058
1033	4100	4142	4184	4226	4268	4310	4353	4395	4437	4479
1034	4521	4563	4605	4647	4689	4730	4772	4814	4856	4898
1035	014940	4982	5024	5066	5108	5150	5192	5234	5276	5318
1036	5360	5402	5444	5485	5527	5569	5611	5653	5695	5737
1037	5779	5821	5863	5904	5946	5988	6030	6072	6114	6156
1038	6197	6239	6281	6323	6365	6407	6448	6490	6532	6574
1039	6616	6657	6699	6741	6783	6824	6866	6908	6950	6992
1040	017033	7075	7117	7159	7200	7242	7284	7326	7367	7409
1041	7451	7492	7534	7576	7618	7659	7701	7743	7784	7826
1042	7868	7909	7951	7993	8034	8076	8118	8159	8201	8243
1043	8284	8326	8368	8409	8451	8492	8534	8576	8617	8659
1044	8700	8742	8784	8825	8867	8908	8950	8992	9033	9075
1045	019116	9158	9199	9241	9282	9324	9366	9407	9449	9490
1046	9532	9573	9615	9656	9698	9739	9781	9822	9864	9905
1047	9947	9988	*0030	*0071	*0113	*0154	*0195	*0237	*0278	*0320
1048	020361	0403	0444	0486	0527	0568	0610	0651	0693	0734
1049	0775	0817	0858	0900	0941	0982	1024	1065	1107	1148
1050	021189	1231	1272	1313	1355	1396	1437	1479	1520	1561

N.	Diff.	1	2	3	4	5	6	7	8	9
PR. PTS.	44	4	9	13	18	22	26	31	35	40
	43	4	9	13	17	22	26	30	34	39
	42	4	8	13	17	21	25	29	34	38
	41	4	8	12	16	21	25	29	33	37
	Diff.	1	2	3	4	5	6	7	8	9

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
— ∞		10.000000		— ∞		— ∞	60
.463726		.000000	.00	6.463726		3.536274	59
.764756	5017.17	.000000	.00	.764756	5017.17	.235244	58
.940847	2934.85	.000000	.00	.940847	2934.85	.059153	57
.065786	2082.32	.000000	.00	7.065786	2082.32	2.934214	56
.162696	1615.17	10.000000	.00	7.162696	1615.17	2.837304	55
.241877	1319.68	9.999999	.02	.241878	1319.70	.758122	54
.308824	1115.78	.999999	.00	.308825	1115.78	.691175	53
.366816	966.53	.999999	.00	.366817	966.53	.633183	52
.417968	852.53	.999999	.00	.417970	852.55	.582030	51
	762.63		.02		762.62		
.463726	689.87	9.999998	.00	7.463727	689.88	2.536273	50
.505118	629.80	.999998	.02	.505120	629.82	.494880	49
.542906	579.37	.999997	.00	.542909	579.38	.457091	48
.577668	536.42	.999997	.02	.577672	536.42	.422328	47
.609853	499.38	.999996	.00	.609857	499.38	.390143	46
.639816	467.15	9.999996	.02	7.639820	467.15	2.360180	45
.667845	438.80	.999995	.00	.667849	438.83	.332151	44
.694173	413.73	.999995	.02	.694179	413.73	.305821	43
.718997	391.35	.999994	.02	.719003	391.35	.280997	42
.742478	371.27	.999993	.00	.742484	371.28	.257516	41
.764754	353.15	9.999993	.02	7.764761	353.17	2.235239	40
.785943	336.72	.999992	.02	.785951	336.73	.214049	39
.806146	321.75	.999991	.02	.806155	321.75	.193845	38
.825451	308.05	.999990	.02	.825460	308.07	.174540	37
.843934	295.47	.999989	.02	.843944	295.50	.156056	36
.861662	283.88	9.999989	.00	7.861674	283.90	2.138326	35
.878695	273.17	.999988	.02	.878708	273.18	.121292	34
.895085	263.23	.999987	.02	.895099	263.25	.104901	33
.910879	254.00	.999986	.02	.910894	254.00	.089106	32
.926119	245.38	.999985	.02	.926134	245.40	.073866	31
.940842	237.33	9.999983	.03	7.940858	237.37	2.059142	30
.955082	229.80	.999982	.02	.955100	229.82	.044900	29
.968870	222.72	.999981	.02	.968889	222.73	.031111	28
.982233	216.08	.999980	.02	.982253	216.10	.017747	27
.995198	209.82	.999979	.02	.995219	209.83	.004781	26
.007787	203.90	9.999977	.03	8.007809	203.92	1.992191	25
.020021	198.30	.999976	.02	.020044	198.35	.979956	24
.031919	193.03	.999975	.02	.031945	193.03	.968055	23
.043501	188.00	.999973	.03	.043527	188.03	.956473	22
.054781	183.25	.999972	.02	.054809	183.28	.945191	21
.065776	178.73	9.999971	.02	8.065806	178.75	1.934194	20
.076500	174.42	.999969	.03	.076531	174.43	.923469	19
.086965	170.30	.999968	.02	.086997	170.33	.913003	18
.097183	166.40	.999966	.03	.097217	166.43	.902783	17
.107167	162.65	.999964	.03	.107203	162.67	.892797	16
.116926	159.08	9.999963	.02	8.116963	159.12	1.883037	15
.126471	155.65	.999961	.03	.126510	155.68	.873490	14
.135810	152.38	.999959	.03	.135851	152.42	.864149	13
.144953	149.23	.999958	.02	.144996	149.27	.855004	12
.153907	146.23	.999956	.03	.153952	146.25	.846048	11
.162681	143.32	9.999954	.03	8.162727	143.35	1.837273	10
.171280	140.55	.999952	.03	.171328	140.58	.828672	9
.179713	137.87	.999950	.03	.179763	137.88	.820237	8
.187985	135.28	.999948	.03	.188036	135.33	.811964	7
.196102	132.80	.999946	.03	.196156	132.83	.803844	6
.204070	130.42	9.999944	.03	8.204126	130.45	1.795874	5
.211895	128.10	.999942	.03	.211953	128.13	.788047	4
.219581	125.88	.999940	.03	.219641	125.90	.780359	3
.227134	123.72	.999938	.03	.227195	123.77	.772805	2
.234557	121.63	.999936	.03	.234621	121.67	.765379	1
.241855		9.999934		8.241921		1.758079	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	8.241855	119.63	9.999934	.03	8.241921	119.68	1
1	.249033	117.68	.999932	.05	.249102	117.72	
2	.256094	115.80	.999929	.03	.256165	115.83	
3	.263042	113.98	.999927	.03	.263115	114.02	
4	.269881	112.22	.999925	.05	.269956	112.25	
5	8.276614	110.48	9.999922	.03	8.276691	110.53	1
6	.283243	108.83	.999920	.03	.283323	108.88	
7	.289773	107.23	.999918	.05	.289856	107.27	
8	.296207	105.65	.999915	.03	.296292	105.70	
9	.302546	104.13	.999913	.05	.302634	104.17	
10	8.308794	102.67	9.999910	.05	8.308884	102.70	1
11	.314954	101.22	.999907	.03	.315046	101.27	
12	.321027	99.82	.999905	.05	.321122	99.87	
13	.327016	98.47	.999902	.05	.327114	98.52	
14	.332924	97.15	.999899	.03	.333025	97.18	
15	8.338753	95.85	9.999897	.05	8.338856	95.90	1
16	.344504	94.62	.999894	.05	.344610	94.65	
17	.350181	93.37	.999891	.05	.350289	93.43	
18	.355783	92.20	.999888	.05	.355895	92.25	
19	.361315	91.03	.999885	.05	.361430	91.08	
20	8.366777	89.90	9.999882	.05	8.366895	89.95	1
21	.372171	88.80	.999879	.05	.372292	88.83	
22	.377499	87.72	.999876	.05	.377622	87.78	
23	.382762	86.67	.999873	.05	.382889	86.72	
24	.387962	85.65	.999870	.05	.388092	85.70	
25	8.393101	84.63	9.999867	.05	8.393234	84.68	1
26	.398179	83.67	.999864	.05	.398315	83.72	
27	.403199	82.70	.999861	.05	.403338	82.77	
28	.408161	81.78	.999858	.07	.408304	81.82	
29	.413068	80.85	.999854	.05	.413213	80.92	
30	8.417919	79.97	9.999851	.05	8.418068	80.02	1
31	.422717	79.08	.999848	.07	.422869	79.15	
32	.427462	78.23	.999844	.05	.427618	78.28	
33	.432156	77.40	.999841	.05	.432315	77.45	
34	.436800	76.57	.999838	.07	.436962	76.63	
35	8.441394	75.78	9.999834	.05	8.441560	75.83	1
36	.445941	74.98	.999831	.07	.446110	75.05	
37	.450440	74.22	.999827	.05	.450613	74.28	
38	.454893	73.47	.999824	.07	.455070	73.52	
39	.459301	72.73	.999820	.07	.459481	72.80	
40	8.463665	72.00	9.999816	.05	8.463849	72.05	1
41	.467985	71.30	.999813	.07	.468172	71.37	
42	.472263	70.58	.999809	.07	.472454	70.65	
43	.476498	69.92	.999805	.07	.476693	69.98	
44	.480693	69.25	.999801	.07	.480892	69.30	
45	8.484848	68.58	9.999797	.05	8.485050	68.67	1
46	.488963	67.95	.999794	.07	.489170	68.00	
47	.493040	67.30	.999790	.07	.493250	67.38	
48	.497078	66.70	.999786	.07	.497293	66.75	
49	.501080	66.08	.999782	.07	.501298	66.15	
50	8.505045	65.48	9.999778	.07	8.505267	65.55	1
51	.508974	64.88	.999774	.08	.509200	64.97	
52	.512867	64.32	.999769	.07	.513098	64.38	
53	.516726	63.75	.999765	.07	.516961	63.82	
54	.520551	63.20	.999761	.07	.520790	63.27	
55	8.524343	62.65	9.999757	.07	8.524586	62.72	1
56	.528102	62.10	.999753	.08	.528349	62.18	
57	.531828	61.58	.999748	.07	.532080	61.65	
58	.535523	61.05	.999744	.07	.535779	61.13	
59	.539186	60.55	.999740	.08	.539447	60.62	
60	8.542819		9.999735		8.543084		
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	

	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.		
9	60.05	9.999735	.07	8.543054	60.12	1.456946	60	
2		.999731	.08	.546691	59.62	.453309	59	
5	59.55	.999726	.07	.550268	59.15	.449732	58	
9	59.07	.999722	.08	.553817	58.65	.446183	57	
4	58.58	.999717	.07	.557336	58.20	.442664	56	
0	58.10	9.999713	.08	8.560828	57.72	1.439172	55	
9	57.65	.999708	.07	.564291	57.27	.435709	54	
1	57.20	.999704	.08	.567727	56.83	.432273	53	
6	56.75	.999699	.08	.571137	56.38	.428863	52	
4	56.30	.999694	.08	.574520	55.95	.425480	51	
5	55.87	9.999689	.07	8.577877	55.52	1.422123	50	
2	55.43	.999685	.08	.581208	55.10	.418792	49	
3	55.02	.999680	.08	.584514	54.68	.415486	48	
9	54.60	.999675	.08	.587795	54.27	.412205	47	
1	54.20	.999670	.08	.591051	53.87	.408949	46	
8	53.78	9.999665	.08	8.594283	53.48	1.405717	45	
2	53.40	.999660	.08	.597492	53.08	.402508	44	
2	53.00	.999655	.08	.600677	52.70	.399323	43	
9	52.62	.999650	.08	.603839	52.32	.396161	42	
3	52.23	.999645	.08	.606978	51.93	.393022	41	
4	51.85	9.999640	.08	8.610094	51.58	1.389906	40	
3	51.48	.999635	.10	.613189	51.22	.386811	39	
1	51.13	.999629	.08	.616262	50.85	.383738	38	
7	50.77	.999624	.08	.619313	50.50	.380687	37	
2	50.42	.999619	.08	.622343	50.15	.377657	36	
5	50.05	9.999614	.10	8.625352	49.80	1.374648	35	
3	49.72	.999608	.08	.628340	49.47	.371660	34	
1	49.38	.999603	.08	.631308	49.13	.368692	33	
4	49.05	.999597	.10	.634256	48.80	.365744	32	
5	48.70	.999592	.08	.637184	48.48	.362816	31	
0	48.40	9.999586	.10	8.640093	48.15	1.359907	30	
3	48.05	.999581	.08	.642982	47.85	.357018	29	
3	47.75	.999575	.10	.645853	47.52	.354147	28	
4	47.43	.999570	.08	.648704	47.22	.351296	27	
2	47.13	.999564	.10	.651537	46.92	.348463	26	
1	46.82	9.999558	.10	8.654352	46.62	1.345648	25	
2	46.52	.999553	.08	.657149	46.32	.342851	24	
5	46.22	.999547	.10	.659928	46.02	.340072	23	
0	45.92	.999541	.10	.662689	45.73	.337311	22	
3	45.63	.999535	.10	.665433	45.45	.334567	21	
9	45.35	9.999529	.08	8.668160	45.17	1.331840	20	
3	45.07	.999524	.10	.670870	44.88	.329130	19	
0	44.78	.999518	.10	.673563	44.60	.326437	18	
1	44.52	.999512	.10	.676239	44.35	.323761	17	
5	44.23	.999506	.10	.678900	44.07	.321100	16	
3	43.97	9.999500	.12	8.681544	43.80	1.318456	15	
5	43.70	.999493	.10	.684172	43.53	.315828	14	
2	43.45	.999487	.10	.686784	43.28	.313216	13	
3	43.18	.999481	.10	.689381	43.03	.310619	12	
8	42.92	.999475	.10	.691963	42.77	.308037	11	
8	42.67	9.999469	.10	8.694529	42.53	1.305471	10	
3	42.42	.999463	.12	.697081	42.27	.302919	9	
3	42.17	.999456	.10	.699617	42.03	.300383	8	
9	41.93	.999450	.12	.702139	41.78	.297861	7	
0	41.68	.999443	.10	.704646	41.57	.295354	6	
7	41.45	9.999437	.10	8.707140	41.30	1.292860	5	
9	41.20	.999431	.12	.709618	41.08	.290382	4	
7	40.97	.999424	.10	.712083	40.85	.287917	3	
2	40.75	.999418	.12	.714534	40.63	.285466	2	
1	40.52	.999411	.12	.716972	40.40	.283028	1	
	40.28	9.999404	.12	8.719396		1.280604	0	
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.		M

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Co
0	8.718800	40.07	9.999404	.10	8.719396	40.17	1.28
1	.721204	39.85	.999398	.12	.721806	39.97	.27
2	.723595	39.62	.999391	.12	.724204	39.73	.27
3	.725972	39.42	.999384	.10	.726588	39.52	.273
4	.728337	39.18	.999378	.12	.728959	39.30	.271
5	8.730688	38.98	9.999371	.12	8.731317	39.10	1.269
6	.733027	38.78	.999364	.12	.733663	38.88	.266
7	.735354	38.55	.999357	.12	.735996	38.68	.264
8	.737667	38.37	.999350	.12	.738317	38.48	.261
9	.739969	38.17	.999343	.12	.740626	38.27	.2593
10	8.742259	37.95	9.999336	.12	8.742922	38.08	1.2570
11	.744536	37.77	.999329	.12	.745207	37.87	.2547
12	.746802	37.55	.999322	.12	.747479	37.68	.25252
13	.749055	37.37	.999315	.12	.749740	37.48	.25026
14	.751297	37.18	.999308	.12	.751989	37.30	.24801
15	8.753528	36.98	9.999301	.12	8.754227	37.10	1.24577
16	.755747	36.80	.999294	.12	.756453	36.92	.24354
17	.757955	36.60	.999287	.13	.758668	36.73	.241332
18	.760151	36.43	.999279	.12	.760872	36.55	.239128
19	.762337	36.23	.999272	.12	.763065	36.35	.236935
20	8.764511	36.07	9.999265	.13	8.765246	36.18	1.234754
21	.766675	35.88	.999257	.12	.767417	36.02	.232583
22	.768828	35.70	.999250	.13	.769578	35.82	.230422
23	.770970	35.52	.999242	.12	.771727	35.65	.228273
24	.773101	35.37	.999235	.13	.773866	35.48	.226134
25	8.775223	35.17	9.999227	.12	8.775995	35.32	1.224005
26	.777333	35.02	.999220	.13	.778114	35.13	.221886
27	.779434	34.83	.999212	.12	.780222	34.97	.219778
28	.781524	34.68	.999205	.13	.782320	34.80	.217680
29	.783605	34.50	.999197	.13	.784408	34.63	.215592
30	8.785675	34.35	9.999189	.13	8.786486	34.47	1.213514
31	.787736	34.18	.999181	.12	.788554	34.32	.211446
32	.789787	34.02	.999174	.13	.790613	34.15	.209387
33	.791828	33.85	.999166	.13	.792662	33.98	.207338
34	.793859	33.70	.999158	.13	.794701	33.83	.205299
35	8.795881	33.55	9.999150	.13	8.796731	33.68	1.203269
36	.797894	33.38	.999142	.13	.798752	33.52	.201248
37	.799897	33.25	.999134	.13	.800763	33.37	.199237
38	.801892	33.07	.999126	.13	.802765	33.22	.197235
39	.803876	32.93	.999118	.13	.804758	33.07	.195242
40	8.805852	32.78	9.999110	.13	8.806742	32.92	1.193258
41	.807819	32.63	.999102	.13	.808717	32.77	.191283
42	.809777	32.48	.999094	.13	.810683	32.63	.189317
43	.811726	32.35	.999086	.15	.81264I	32.47	.187359
44	.813667	32.20	.999077	.13	.814589	32.33	.185411
45	8.815599	32.05	9.999069	.13	8.816529	32.20	1.183471
46	.817522	31.90	.999061	.13	.818461	32.05	.181539
47	.819436	31.78	.999053	.15	.820384	31.90	.179616
48	.821343	31.62	.999044	.13	.822298	31.78	.177702
49	.823240	31.50	.999036	.15	.824205	31.63	.175795
50	8.825130	31.35	9.999027	.13	8.826103	31.48	1.173897
51	.827011	31.22	.999019	.15	.827992	31.37	.172008
52	.828884	31.08	.999010	.13	.829874	31.23	.170126
53	.830749	30.97	.999002	.15	.831748	31.08	.168252
54	.832607	30.82	.998993	.15	.833613	30.97	.166387
55	8.834456	30.68	9.998984	.15	8.835471	30.83	1.164529
56	.836297	30.55	.998976	.13	.837321	30.70	.162679
57	.838130	30.43	.998967	.15	.839163	30.58	.160837
58	.839956	30.30	.998958	.15	.840998	30.45	.159002
59	.841774	30.18	.998950	.13	.842825	30.32	.157175
60	8.843585		9.998941	.15	8.844644		1.155356
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
.843585	30. 03	9. 998941	.15	8. 844644	30. 18	1. 155356	60
.845387	29. 93	.998932	.15	.846455	30. 08	.153545	59
.847183	29. 80	.998923	.15	.848260	29. 95	.151740	58
.848971	29. 67	.998914	.15	.850057	29. 82	.149943	57
.850751	29. 57	.998905	.15	.851846	29. 70	.148154	56
.852525	29. 43	9. 998896	.15	8. 853628	29. 58	1. 146372	55
.854291	29. 30	.998887	.15	.855403	29. 47	.144597	54
.856049	29. 20	.998878	.15	.857171	29. 35	.142829	53
.857801	29. 08	.998869	.15	.858932	29. 23	.141068	52
.859546	28. 95	.998860	.15	.860686	29. 12	.139314	51
8. 861283	28. 85	9. 998851	.17	8. 862433	29. 00	1. 137567	50
.863014	28. 73	.998841	.15	.864173	28. 88	.135827	49
.864738	28. 62	.998832	.15	.865906	28. 77	.134094	48
.866455	28. 50	.998823	.17	.867632	28. 65	.132368	47
.868165	28. 38	.998813	.15	.869351	28. 55	.130649	46
8. 869868	28. 28	9. 998804	.15	8. 871064	28. 43	1. 128936	45
.871565	28. 17	.998795	.17	.872770	28. 32	.127230	44
.873255	28. 05	.998785	.15	.874469	28. 22	.125531	43
.874938	27. 95	.998776	.17	.876162	28. 12	.123838	42
.876615	27. 83	.998766	.15	.877849	28. 00	.122151	41
8. 878285	27. 73	9. 998757	.17	8. 879529	27. 88	1. 120471	40
.879949	27. 63	.998747	.15	.881202	27. 78	.118798	39
.881607	27. 52	.998738	.17	.882869	27. 68	.117131	38
.883258	27. 42	.998728	.17	.884530	27. 58	.115470	37
.884903	27. 32	.998718	.17	.886185	27. 47	.113815	36
8. 886542	27. 20	9. 998708	.15	8. 887833	27. 38	1. 112167	35
.888174	27. 12	.998699	.17	.889476	27. 27	.110524	34
.889801	27. 00	.998689	.17	.891112	27. 17	.108888	33
.891421	26. 90	.998679	.17	.892742	27. 07	.107258	32
.893035	26. 80	.998669	.17	.894366	26. 97	.105634	31
8. 894643	26. 72	9. 998659	.17	8. 895984	26. 87	1. 104016	30
.896246	26. 60	.998649	.17	.897596	26. 78	.102404	29
.897842	26. 50	.998639	.17	.899203	26. 67	.100797	28
.899432	26. 42	.998629	.17	.900803	26. 58	.099197	27
.901017	26. 32	.998619	.17	.902398	26. 48	.097602	26
8. 902596	26. 22	9. 998609	.17	8. 903987	26. 38	1. 096013	25
.904169	26. 12	.998599	.17	.905570	26. 28	.094430	24
.905736	26. 02	.998589	.18	.907147	26. 20	.092853	23
.907297	25. 93	.998578	.17	.908719	26. 10	.091281	22
.908853	25. 85	.998568	.17	.910285	26. 02	.089715	21
8. 910404	25. 75	9. 998558	.17	8. 911846	25. 92	1. 088154	20
.911949	25. 65	.998548	.18	.913401	25. 83	.086599	19
.913488	25. 57	.998537	.17	.914951	25. 73	.085049	18
.915022	25. 47	.998527	.18	.916495	25. 65	.083505	17
.916550	25. 38	.998516	.17	.918034	25. 57	.081966	16
8. 918073	25. 30	9. 998506	.18	8. 919568	25. 47	1. 080432	15
.919591	25. 20	.998495	.17	.921096	25. 38	.078904	14
.921103	25. 12	.998485	.18	.922619	25. 28	.077381	13
.922610	25. 03	.998474	.17	.924136	25. 22	.075864	12
.924112	24. 95	.998464	.18	.925649	25. 12	.074351	11
8. 925609	24. 85	9. 998453	.18	8. 927156	25. 03	1. 072844	10
.927100	24. 78	.998442	.18	.928658	24. 95	.071342	9
.928587	24. 68	.998431	.17	.930155	24. 87	.069845	8
.930068	24. 60	.998421	.18	.931647	24. 78	.068353	7
.931544	24. 52	.998410	.18	.933134	24. 70	.066866	6
8. 933015	24. 43	9. 998399	.18	8. 934616	24. 62	1. 065384	5
.934481	24. 35	.998388	.18	.936093	24. 53	.063907	4
.935942	24. 27	.998377	.18	.937565	24. 45	.062435	3
.937398	24. 20	.998366	.18	.939032	24. 37	.060968	2
.938850	24. 10	.998355	.18	.940494	24. 30	.059506	1
8. 940296		9. 998344		8. 941952		1. 058048	0
Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
0	9.085894	17.13	9.996751	.27	9.089144	17.38	0.910856	60
1	.086422	17.08	.996735	.25	.090187	17.35	.909813	59
2	.087947	17.05	.996720	.27	.091228	17.30	.908772	58
3	.088970	17.00	.996704	.27	.092266	17.27	.907734	57
4	.089990	16.97	.996688	.25	.093302	17.23	.906698	56
5	9.091008	16.93	9.996673	.27	9.094336	17.18	0.905664	55
6	.092024	16.88	.996657	.27	.095367	17.13	.904633	54
7	.093037	16.83	.996641	.27	.096395	17.12	.903605	53
8	.094047	16.82	.996625	.25	.097422	17.07	.902578	52
9	.095056	16.77	.996610	.27	.098446	17.03	.901554	51
10	9.096062	16.72	9.996594	.27	9.099468	16.98	0.900532	50
11	.097065	16.68	.996578	.27	.100487	16.95	.899513	49
12	.098066	16.65	.996562	.27	.101504	16.92	.898496	48
13	.099065	16.62	.996546	.27	.102519	16.88	.897481	47
14	.100062	16.57	.996530	.27	.103532	16.83	.896468	46
15	9.101056	16.53	9.996514	.27	9.104542	16.80	0.895458	45
16	.102048	16.48	.996498	.27	.105550	16.77	.894450	44
17	.103037	16.47	.996482	.28	.106556	16.72	.893444	43
18	.104025	16.42	.996465	.27	.107559	16.68	.892441	42
19	.105010	16.37	.996449	.27	.108560	16.65	.891440	41
20	9.105992	16.35	9.996433	.27	9.109559	16.62	0.890441	40
21	.106973	16.30	.996417	.28	.110556	16.58	.889444	39
22	.107951	16.27	.996400	.27	.111551	16.53	.888449	38
23	.108927	16.23	.996384	.27	.112543	16.50	.887457	37
24	.109901	16.20	.996368	.28	.113533	16.47	.886467	36
25	9.110873	16.15	9.996351	.27	9.114521	16.43	0.885479	35
26	.111842	16.12	.996335	.28	.115507	16.40	.884493	34
27	.112809	16.08	.996318	.27	.116491	16.35	.883509	33
28	.113774	16.05	.996302	.28	.117472	16.33	.882528	32
29	.114737	16.02	.996285	.27	.118452	16.28	.881548	31
30	9.115698	15.97	9.996269	.28	9.119429	16.25	0.880571	30
31	.116656	15.95	.996252	.28	.120404	16.22	.879596	29
32	.117613	15.90	.996235	.27	.121377	16.18	.878623	28
33	.118567	15.87	.996219	.28	.122348	16.15	.877652	27
34	.119519	15.83	.996202	.28	.123317	16.12	.876683	26
35	9.120469	15.80	9.996185	.28	9.124284	16.08	0.875716	25
36	.121417	15.75	.996168	.28	.125249	16.03	.874751	24
37	.122362	15.73	.996151	.28	.126211	16.02	.873789	23
38	.123306	15.70	.996134	.28	.127172	15.97	.872828	22
39	.124248	15.65	.996117	.28	.128130	15.95	.871870	21
40	9.125187	15.63	9.996100	.28	9.129087	15.90	0.870913	20
41	.126125	15.58	.996083	.28	.130041	15.88	.869959	19
42	.127060	15.55	.996066	.28	.130994	15.83	.869006	18
43	.127993	15.53	.996049	.28	.131944	15.82	.868056	17
44	.128925	15.48	.996032	.28	.132893	15.77	.867107	16
45	9.129854	15.45	9.996015	.28	9.133839	15.75	0.866161	15
46	.130781	15.42	.995998	.30	.134784	15.70	.865216	14
47	.131709	15.40	.995980	.28	.135726	15.68	.864274	13
48	.132630	15.35	.995963	.28	.136667	15.63	.863333	12
49	.133551	15.32	.995946	.30	.137605	15.62	.862395	11
50	9.134470	15.28	9.995928	.28	9.138542	15.57	0.861458	10
51	.135387	15.27	.995911	.28	.139476	15.55	.860524	9
52	.136303	15.22	.995894	.30	.140409	15.52	.859591	8
53	.137216	15.20	.995876	.28	.141340	15.48	.858660	7
54	.138128	15.15	.995859	.30	.142269	15.45	.857731	6
55	9.139037	15.12	9.995841	.30	9.143196	15.42	0.856804	5
56	.139944	15.10	.995823	.28	.144121	15.38	.855879	4
57	.140850	15.07	.995806	.30	.145044	15.37	.854956	3
58	.141754.	15.02	.995788	.30	.145966	15.32	.854034	2
59	.142655	15.00	.995771	.28	.146885	15.30	.853115	1
60	9.143555		9.995753	.30	9.147803		0.852197	0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
5	14.97	9.995753	.30	9.147803	15.25	0.852197	60
3	14.93	.995735	.30	.148718	15.23	.851282	59
9	14.90	.995717	.30	.149632	15.20	.850368	58
3	14.88	.995699	.30	.150544	15.17	.849456	57
6	14.83	.995681	.28	.151454	15.15	.848546	56
6	14.82	9.995664	.30	9.152363	15.10	0.847637	55
5	14.78	.995646	.30	.153269	15.08	.846731	54
2	14.73	.995628	.30	.154174	15.05	.845826	53
6	14.72	.995610	.32	.155077	15.02	.844923	52
9	14.70	.995591	.30	.155978	14.98	.844022	51
1	14.65	9.995573	.30	9.156877	14.97	0.843123	50
0	14.63	.995555	.30	.157775	14.93	.842225	49
8	14.58	.995537	.30	.158671	14.90	.841329	48
3	14.57	.995519	.30	.159565	14.87	.840435	47
7	14.55	.995501	.32	.160457	14.83	.839543	46
5	14.50	9.995482	.30	9.161347	14.82	0.838653	45
0	14.48	.995464	.30	.162236	14.78	.837764	44
9	14.43	.995446	.32	.163123	14.75	.836877	43
5	14.43	.995427	.30	.164008	14.73	.835992	42
1	14.38	.995409	.32	.164892	14.70	.835108	41
4	14.35	9.995390	.30	9.165774	14.67	0.834226	40
5	14.33	.995372	.32	.166654	14.63	.833346	39
5	14.30	.995353	.32	.167532	14.62	.832468	38
3	14.28	.995334	.30	.168409	14.58	.831591	37
0	14.23	.995316	.32	.169284	14.55	.830716	36
4	14.22	9.995297	.32	9.170157	14.53	0.829843	35
7	14.20	.995278	.30	.171029	14.50	.828971	34
2	14.15	.995260	.32	.171899	14.47	.828101	33
8	14.13	.995241	.32	.172767	14.45	.827233	32
5	14.10	.995222	.32	.173634	14.42	.826366	31
8	14.08	9.995203	.32	9.174499	14.38	0.825501	30
1	14.03	.995184	.32	.175362	14.37	.824638	29
4	14.02	.995165	.32	.176224	14.33	.823776	28
1	14.00	.995146	.32	.177084	14.30	.822916	27
	13.97	.995127	.32	.177942	14.28	.822058	26
	13.93	9.995108	.32	9.178799	14.27	0.821201	25
	13.90	.995089	.32	.179655	14.22	.820345	24
	13.88	.995070	.32	.180508	14.20	.819492	23
	13.85	.995051	.32	.181360	14.18	.818640	22
	13.83	.995032	.32	.182211	14.13	.817789	21
	13.80	9.995013	.33	9.183059	14.13	0.816941	20
	13.77	.994993	.32	.183907	14.08	.816093	19
	13.75	.994974	.32	.184752	14.08	.815248	18
	13.72	.994955	.33	.185597	14.03	.814403	17
	13.70	.994935	.32	.186439	14.02	.813561	16
	13.67	9.994916	.33	9.187280	14.00	0.812720	15
	13.63	.994896	.32	.188120	13.97	.811880	14
	13.62	.994877	.33	.188958	13.93	.811042	13
	13.58	.994857	.32	.189794	13.92	.810206	12
	13.57	.994838	.33	.190629	13.88	.809371	11
	13.53	9.994818	.33	9.191462	13.87	0.808538	10
	13.52	.994798	.32	.192294	13.83	.807706	9
	13.48	.994779	.33	.193124	13.82	.806876	8
	13.45	.994759	.33	.193953	13.78	.806047	7
	13.43	.994739	.32	.194780	13.77	.805220	6
	13.42	9.994720	.33	9.195606	13.73	0.804394	5
	13.38	.994700	.33	.196430	13.72	.803570	4
	13.35	.994680	.33	.197253	13.68	.802747	3
	13.33	.994660	.33	.198074	13.67	.801926	2
	13.30	.994640	.33	.198894	13.65	.801106	1
		9.994620		9.199713		0.800287	0
	′.	Sin.	D. 1″.	Cot.	D. 1′.	Tan.	M.

81°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9. 194332	13. 28	9. 994620	.33	9. 199713	13. 60	
1	.195129	13. 27	.994600	.33	.200529	13. 60	
2	.195925	13. 23	.994580	.33	.201345	13. 57	
3	.196719	13. 20	.994560	.33	.202159	13. 53	
4	.197511	13. 18	.994540	.35	.20297I	13. 52	
5	9. 198302	13. 15	9. 994519	.33	9. 203782	13. 50	
6	.199091	13. 13	.994499	.33	.204592	13. 47	
7	.199879	13. 12	.994479	.33	.205400	13. 45	
8	.200666	13. 08	.994459	.35	.206207	13. 43	
9	.201451	13. 05	.994438	.33	.207013	13. 40	
10	9. 202234	13. 05	9. 994418	.33	9. 207817	13. 37	0
11	.203017	13. 00	.994398	.35	.208619	13. 35	.
12	.203797	13. 00	.994377	.33	.209420	13. 33	.
13	.204577	12. 95	.994357	.35	.210220	13. 30	.
14	.205354	12. 95	.994336	.33	.211018	13. 28	.
15	9. 206131	12. 92	9. 994316	.35	9. 211815	13. 27	0.
16	.206906	12. 88	.994295	.35	.21261I	13. 23	.
17	.207679	12. 88	.994274	.33	.213405	13. 22	.
18	.208452	12. 83	.994254	.35	.214198	13. 18	.7
19	.209222	12. 83	.994233	.35	.214989	13. 18	.7
20	9. 209992	12. 80	9. 994212	.35	9. 215780	13. 13	0.7
21	.210760	12. 77	.994191	.33	.216568	13. 13	.7
22	.211526	12. 75	.994171	.35	.217356	13. 10	.78
23	.212291	12. 73	.994150	.35	.218142	13. 07	.78
24	.213055	12. 72	.994129	.35	.218926	13. 07	.78
25	9. 213818	12. 68	9. 994108	.35	9. 219710	13. 03	0.78
26	.214579	12. 65	.994087	.35	.220492	13. 00	.775
27	.215338	12. 65	.994066	.35	.221272	13. 00	.778
28	.216097	12. 62	.994045	.35	.222052	12. 97	.777
29	.216854	12. 58	.994024	.35	.222830	12. 95	.777
30	9. 217609	12. 57	9. 994003	.35	9. 223607	12. 92	0. 7763
31	.218363	12. 55	.993982	.37	.224382	12. 90	.7756
32	.219116	12. 53	.993960	.35	.225156	12. 88	.7748
33	.219868	12. 50	.993939	.35	.225929	12. 85	.7740
34	.220618	12. 48	.993918	.35	.226700	12. 85	.7733
35	9. 221367	12. 47	9. 993897	.37	9. 227471	12. 80	0. 7725
36	.222115	12. 43	.993875	.35	.228239	12. 80	.7717
37	.222861	12. 42	.993854	.37	.229007	12. 77	.7709
38	.223606	12. 38	.993832	.35	.229773	12. 77	.7702
39	.224349	12. 38	.993811	.37	.230539	12. 72	.7694
40	9. 225092	12. 35	9. 993789	.35	9. 231302	12. 72	0. 7686
41	.225833	12. 33	.993768	.37	.232065	12. 68	.7679
42	.226573	12. 30	.993746	.35	.232826	12. 67	.7671
43	.227311	12. 28	.993725	.37	.233586	12. 65	.7664
44	.228048	12. 27	.993703	.37	.234345	12. 63	.7656
45	9. 228784	12. 23	9. 993681	.35	9. 235103	12. 60	0. 7648
46	.229518	12. 23	.993660	.37	.235859	12. 58	.7641
47	.230252	12. 20	.993638	.37	.236614	12. 57	.7633
48	.230984	12. 18	.993616	.37	.237368	12. 53	.7626
49	.231715	12. 15	.993594	.37	.238120	12. 53	.7618
50	9. 232444	12. 13	9. 993572	.37	9. 238872	12. 50	0. 7611
51	.233172	12. 12	.993550	.37	.239622	12. 48	.7603
52	.233899	12. 10	.993528	.37	.240371	12. 45	.7596
53	.234625	12. 07	.993506	.37	.241118	12. 45	.7588
54	.235349	12. 07	.993484	.37	.241865	12. 42	.7581
55	9. 236073	12. 03	9. 993462	.37	9. 242610	12. 40	0. 7573
56	.236795	12. 00	.993440	.37	.243354	12. 38	.7566
57	.237515	12. 00	.993418	.37	.244097	12. 37	.7559
58	.238235	11. 97	.993396	.37	.244839	12. 33	.7551
59	.238953	11. 95	.993374	.38	.245579	12. 33	.7544
60	9. 239670		9. 993351		9. 246319		0. 753
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
11.93	9.993351	.37	9.246319	12.30	0.753681	60
11.92	.993329	.37	.247057	12.28	.752943	59
11.88	.993307	.38	.247794	12.27	.752206	58
11.87	.993284	.37	.248530	12.23	.751470	57
11.85	.993262	.37	.249264	12.23	.750736	56
11.83	9.993240	.38	9.249998	12.20	0.750002	55
11.82	.993217	.37	.250730	12.18	.749270	54
11.78	.993195	.38	.251461	12.17	.748539	53
11.77	.993172	.38	.252191	12.15	.747809	52
11.77	.993149	.37	.252920	12.13	.747080	51
11.72	9.993127	.38	9.253648	12.10	0.746352	50
11.72	.993104	.38	.254374	12.10	.745626	49
11.70	.993081	.37	.255100	12.07	.744900	48
11.67	.993059	.38	.255824	12.05	.744176	47
11.65	.993036	.38	.256547	12.03	.743453	46
11.63	9.993013	.38	9.257269	12.02	0.742731	45
11.62	.992990	.38	.257990	12.00	.742010	44
11.60	.992967	.38	.258710	11.98	.741290	43
11.57	.992944	.38	.259429	11.95	.740571	42
11.57	.992921	.38	.260146	11.95	.739854	41
11.53	9.992898	.38	9.260863	11.92	0.739137	40
11.52	.992875	.38	.261578	11.90	.738422	39
11.50	.992852	.38	.262292	11.88	.737708	38
11.48	.992829	.38	.263005	11.87	.736995	37
11.47	.992806	.38	.263717	11.85	.736283	36
11.45	9.992783	.40	9.264428	11.83	0.735572	35
11.42	.992759	.38	.265138	11.82	.734862	34
11.42	.992736	.38	.265847	11.80	.734153	33
11.38	.992713	.38	.266555	11.77	.733445	32
11.37	.992690	.40	.267261	11.77	.732739	31
11.35	9.992666	.38	9.267967	11.73	0.732033	30
11.33	.992643	.40	.268671	11.73	.731329	29
11.32	.992619	.38	.269375	11.70	.730625	28
11.30	.992596	.40	.270077	11.70	.729923	27
11.27	.992572	.38	.270779	11.67	.729221	26
11.27	9.992549	.40	9.271479	11.65	0.728521	25
11.23	.992525	.40	.272178	11.63	.727822	24
11.23	.992501	.38	.272876	11.62	.727124	23
11.20	.992478	.40	.273573	11.60	.726427	22
11.20	.992454	.40	.274269	11.58	.725731	21
11.17	9.992430	.40	9.274964	11.57	0.725036	20
11.15	.992406	.40	.275658	11.55	.724342	19
11.13	.992382	.38	.276351	11.53	.723649	18
11.12	.992359	.40	.277043	11.52	.722957	17
11.10	.992335	.40	.277734	11.50	.722266	16
11.08	9.992311	.40	9.278424	11.48	0.721576	15
11.07	.992287	.40	.279113	11.47	.720887	14
11.03	.992263	.40	.279801	11.45	.720199	13
11.03	.992239	.42	.280488	11.43	.719512	12
11.02	.992214	.40	.281174	11.40	.718826	11
11.00	9.992190	.40	9.281858	11.40	0.718142	10
10.98	.992166	.40	.282542	11.38	.717458	9
10.97	.992142	.40	.283225	11.37	.716775	8
10.95	.992118	.42	.283907	11.35	.716093	7
10.93	.992093	.40	.284588	11.33	.715412	6
10.92	9.992069	.42	9.285268	11.32	0.714732	5
10.90	.992044	.40	.285947	11.28	.714053	4
10.88	.992020	.40	.286624	11.28	.713376	3
10.87	.991996	.42	.287301	11.27	.712699	2
10.85	.991971	.40	.287977	11.25	.712023	1
10.83	9.991947		9.288652		0.711348	0
	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.280599	10.82	9.991947	.42	9.288652	11.23	
1	.281248	10.82	.991922	.42	.289326	11.22	
2	.281897	10.78	.991897	.40	.289999	11.20	
3	.282544	10.77	.991873	.42	.290671	11.18	
4	.283190	10.77	.991848	.42	.291342	11.18	
5	9.283836	10.73	9.991823	.40	9.292013	11.15	
6	.284480	10.73	.991799	.42	.292682	11.13	
7	.285124	10.70	.991774	.42	.293350	11.12	
8	.285766	10.70	.991749	.42	.294017	11.12	
9	.286408	10.67	.991724	.42	.294684	11.08	
10	9.287048	10.67	9.991699	.42	9.295349	11.07	
11	.287688	10.63	.991674	.42	.296013	11.07	
12	.288326	10.63	.991649	.42	.296677	11.03	
13	.288964	10.60	.991624	.42	.297339	11.03	
14	.289600	10.60	.991599	.42	.298001	11.02	
15	9.290236	10.57	9.991574	.42	9.298662	11.00	0
16	.290870	10.57	.991549	.42	.299322	10.97	.
17	.291504	10.55	.991524	.43	.299980	10.97	.
18	.292137	10.52	.991498	.42	.300638	10.95	.
19	.292768	10.52	.991473	.42	.301295	10.93	.
20	9.293399	10.50	9.991448	.43	9.301951	10.93	0.
21	.294029	10.48	.991422	.42	.302607	10.90	.
22	.294658	10.47	.991397	.42	.303261	10.88	.
23	.295286	10.45	.991372	.43	.303914	10.88	.
24	.295913	10.43	.991346	.42	.304567	10.85	.
25	9.296539	10.42	9.991321	.43	9.305218	10.85	0.
26	.297164	10.40	.991295	.42	.305869	10.83	.
27	.297788	10.40	.991270	.43	.306519	10.82	.
28	.298412	10.37	.991244	.43	.307168	10.80	.
29	.299034	10.35	.991218	.42	.307816	10.78	.69
30	9.299655	10.35	9.991193	.43	9.308463	10.77	0.69
31	.300276	10.32	.991167	.43	.309109	10.75	.69
32	.300895	10.32	.991141	.43	.309754	10.75	.69
33	.301514	10.30	.991115	.42	.310399	10.72	.68
34	.302132	10.27	.991090	.43	.311042	10.72	.68
35	9.302748	10.27	9.991064	.43	9.311685	10.70	0.68
36	.303364	10.25	.991038	.43	.312327	10.68	.68
37	.303979	10.23	.991012	.43	.312968	10.67	.68
38	.304593	10.23	.990986	.43	.313608	10.65	.68
39	.305207	10.20	.990960	.43	.314247	10.63	.68
40	9.305819	10.18	9.990934	.43	9.314885	10.63	0.68
41	.306430	10.18	.990908	.43	.315523	10.60	.68
42	.307041	10.15	.990882	.45	.316159	10.60	.68
43	.307650	10.15	.990855	.43	.316795	10.58	.68
44	.308259	10.13	.990829	.43	.317430	10.57	.68
45	9.308867	10.12	9.990803	.43	9.318064	10.55	0.68
46	.309474	10.10	.990777	.45	.318697	10.55	.68
47	.310080	10.08	.990750	.43	.319330	10.52	.68
48	.310685	10.07	.990724	.45	.319961	10.52	.68
49	.311289	10.07	.990697	.43	.320592	10.50	.67
50	9.311893	10.03	9.990671	.43	9.321222	10.48	0.67
51	.312495	10.03	.990645	.45	.321851	10.47	.67
52	.313097	10.02	.990618	.45	.322479	10.45	.67
53	.313698	9.98	.990591	.43	.323106	10.45	.67
54	.314297	10.00	.990565	.45	.323733	10.42	.67
55	9.314897	9.97	9.990538	.45	9.324358	10.42	0.67
56	.315495	9.95	.990511	.43	.324983	10.40	.67
57	.316092	9.95	.990485	.45	.325607	10.40	.67
58	.316689	9.92	.990458	.45	.326231	10.37	.67
59	.317284	9.92	.990431	.45	.326853	10.37	.67
60	9.317879		9.990404	.45	9.327475		0.67
/	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.239670	11.93	9.993351	.37	9.246319	12.30	0.753681	60
.240386	11.92	.993329	.37	.247057	12.28	.752943	59
.241101	11.88	.993307	.38	.247794	12.27	.752206	58
.241814	11.87	.993284	.37	.248530	12.23	.751470	57
.242526	11.85	.993262	.37	.249264	12.23	.750736	56
9.243237	11.83	9.993240	.38	9.249998	12.20	0.750002	55
.243947	11.82	.993217	.37	.250730	12.18	.749270	54
.244656	11.78	.993195	.38	.251461	12.17	.748539	53
.245363	11.77	.993172	.38	.252191	12.15	.747809	52
.246069	11.77	.993149	.37	.252920	12.13	.747080	51
9.246775	11.72	9.993127	.38	9.253648	12.10	0.746352	50
.247478	11.72	.993104	.38	.254374	12.10	.745626	49
.248181	11.70	.993081	.37	.255100	12.07	.744900	48
.248883	11.67	.993059	.38	.255824	12.05	.744176	47
.249583	11.65	.993036	.38	.256547	12.03	.743453	46
9.250282	11.63	9.993013	.38	9.257269	12.02	0.742731	45
.250980	11.62	.992990	.38	.257990	12.00	.742010	44
.251677	11.60	.992967	.38	.258710	11.98	.741290	43
.252373	11.57	.992944	.38	.259429	11.95	.740571	42
.253067	11.57	.992921	.38	.260146	11.95	.739854	41
9.253761	11.53	9.992898	.38	9.260863	11.92	0.739137	40
.254453	11.52	.992875	.38	.261578	11.90	.738422	39
.255144	11.50	.992852	.38	.262292	11.88	.737708	38
.255834	11.48	.992829	.38	.263005	11.87	.736995	37
.256523	11.47	.992806	.38	.263717	11.85	.736283	36
9.257211	11.45	9.992783	.40	9.264428	11.83	0.735572	35
.257898	11.42	.992759	.38	.265138	11.82	.734862	34
.258583	11.42	.992736	.38	.265847	11.80	.734153	33
.259268	11.38	.992713	.38	.266555	11.77	.733445	32
.259951	11.37	.992690	.40	.267261	11.77	.732739	31
9.260633	11.35	9.992666	.38	9.267967	11.73	0.732033	30
.261314	11.33	.992643	.40	.268671	11.73	.731329	29
.261994	11.32	.992619	.38	.269375	11.70	.730625	28
.262673	11.30	.992596	.40	.270077	11.70	.729923	27
.263351	11.27	.992572	.38	.270779	11.67	.729221	26
9.264027	11.27	9.992549	.40	9.271479	11.65	0.728521	25
.264703	11.23	.992525	.40	.272178	11.63	.727822	24
.265377	11.23	.992501	.38	.272876	11.62	.727124	23
.266051	11.20	.992478	.40	.273573	11.60	.726427	22
.266723	11.20	.992454	.40	.274269	11.58	.725731	21
.267395	11.17	9.992430	.40	9.274964	11.57	0.725036	20
.268065	11.15	.992406	.40	.275658	11.55	.724342	19
.268734	11.13	.992382	.38	.276351	11.53	.723649	18
269402	11.12	.992359	.40	.277043	11.52	.722957	17
270069	11.10	.992335	.40	.277734	11.50	.722266	16
270735	11.08	9.992311	.40	9.278424	11.48	0.721576	15
271400	11.07	.992287	.40	.279113	11.47	.720887	14
272064	11.03	.992263	.40	.279801	11.45	.720199	13
272726	11.03	.992239	.42	.280488	11.43	.719512	12
273388	11.02	.992214	.40	.281174	11.40	.718826	11
74049	10.98	9.992190	.40	9.281858	11.40	0.718142	10
74708	10.98	.992166	.40	.282542	11.38	.717458	9
75367	10.97	.992142	.40	.283225	11.37	.716775	8
76025	10.93	.992118	.42	.283907	11.35	.716093	7
76681	10.93	.992093	.40	.284588	11.33	.715412	6
77337	10.90	9.992069	.42	9.285268	11.32	0.714732	5
77991	10.90	.992044	.40	.285947	11.28	.714053	4
78645	10.90	.992020	.40	.286624	11.28	.713376	3
79297	10.87	.991996	.42	.287301	11.27	.712699	2
79948	10.85	.991971	.40	.287977	11.25	.712023	1
80599	10.85	9.991947		9.288652		0.711348	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.352088	9.12	9.988724	.48	9.363364	9.60	
1	.352635	9.10	.988695	.48	.363940	9.58	
2	.353181	9.08	.988666	.50	.364515	9.58	
3	.353726	9.08	.988636	.48	.365090	9.57	
4	.354271	9.07	.988607	.48	.365664	9.55	
5	9.354815	9.05	9.988578	.50	9.366237	9.55	
6	.355358	9.05	.988548	.48	.366810	9.53	
7	.355901	9.03	.988519	.50	.367382	9.52	
8	.356443	9.02	.988489	.48	.367953	9.52	
9	.356984	9.00	.988460	.50	.368524	9.50	
10	9.357524	9.00	9.988430	.48	9.369094	9.48	0.
11	.358064	8.98	.988401	.50	.369663	9.48	.
12	.358603	8.97	.988371	.48	.370232	9.45	.
13	.359141	8.95	.988342	.50	.370799	9.47	.
14	.359678	8.95	.988312	.50	.371367	9.43	.
15	9.360215	8.95	9.988282	.50	9.371933	9.43	0.
16	.360752	8.92	.988252	.48	.372499	9.42	.6
17	.361287	8.92	.988223	.50	.373064	9.42	.6
18	.361822	8.90	.988193	.50	.373629	9.40	.6
19	.362356	8.88	.988163	.50	.374193	9.38	.6
20	9.362889	8.88	9.988133	.50	9.374756	9.38	0.62
21	.363422	8.87	.988103	.50	.375319	9.37	.62
22	.363954	8.85	.988073	.50	.375881	9.35	.62
23	.364485	8.85	.988043	.50	.376442	9.35	.62
24	.365016	8.83	.988013	.50	.377003	9.33	.622
25	9.365546	8.82	9.987983	.50	9.377563	9.32	0.622
26	.366075	8.82	.987953	.52	.378122	9.32	.621
27	.366604	8.78	.987922	.50	.378681	9.30	.621
28	.367131	8.80	.987892	.50	.379239	9.30	.620
29	.367659	8.77	.987862	.50	.379797	9.28	.620
30	9.368185	8.77	9.987832	.52	9.380354	9.27	0.6196
31	.368711	8.75	.987801	.50	.380910	9.27	.6190
32	.369236	8.75	.987771	.52	.381466	9.23	.6185
33	.369761	8.73	.987740	.50	.382020	9.25	.6179
34	.370285	8.72	.987710	.52	.382575	9.23	.6174
35	9.370808	8.70	9.987679	.50	9.383129	9.22	0.6168
36	.371330	8.70	.987649	.52	.383682	9.20	.6163
37	.371852	8.68	.987618	.50	.384234	9.20	.6157
38	.372373	8.68	.987588	.52	.384786	9.18	.6152
39	.372894	8.67	.987557	.52	.385337	9.18	.6146
40	9.373414	8.65	9.987526	.50	9.385888	9.17	0.6141
41	.373933	8.65	.987496	.52	.386438	9.15	.6135
42	.374452	8.63	.987465	.52	.386987	9.15	.6130
43	.374970	8.62	.987434	.52	.387536	9.13	.6124
44	.375487	8.60	.987403	.52	.388084	9.12	.6119
45	9.376003	8.60	9.987372	.52	9.388631	9.12	0.6113
46	.376519	8.60	.987341	.52	.389178	9.10	.6108
47	.377035	8.57	.987310	.52	.389724	9.10	.6102
48	.377549	8.57	.987279	.52	.390270	9.08	.6097
49	.378063	8.57	.987248	.52	.390815	9.08	.6091
50	9.378577	8.53	9.987217	.52	9.391360	9.05	0.6086
51	.379089	8.53	.987186	.52	.391903	9.07	.6080
52	.379601	8.53	.987155	.52	.392447	9.03	.6075
53	.380113	8.52	.987124	.52	.392989	9.03	.6070
54	.380624	8.50	.987092	.53	.393531	9.03	.6064
55	9.381134	8.48	9.987061	.52	9.394073	9.02	0.6059
56	.381643	8.48	.987030	.52	.394614	9.00	.6053
57	.382152	8.48	.986998	.53	.395154	9.00	.6048
58	.382661	8.45	.986967	.52	.395694	8.98	.6043
59	.383168	8.45	.986936	.52	.396233	8.97	.6037
60	9.383675		9.986904	.53	9.396771		0.6032
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
.383675	8.45	9.986904	.52	9.396771	8.97	0.603229	60
.384182	8.42	.986873	.53	.397309	8.95	.602691	59
.384687	8.42	.986841	.53	.397846	8.95	.602154	58
.385192	8.42	.986809	.52	.398383	8.93	.601617	57
.385697	8.40	.986778	.53	.398919	8.93	.601081	56
.386201	8.38	9.986746	.53	9.399455	8.92	0.600545	55
.386704	8.38	.986714	.52	.399990	8.90	.600010	54
.387207	8.37	.986683	.53	.400524	8.90	.599476	53
.387709	8.35	.986651	.53	.401058	8.88	.598942	52
.388210	8.35	.986619	.53	.401591	8.88	.598409	51
.388711	8.33	9.986587	.53	9.402124	8.87	0.597876	50
.389211	8.33	.986555	.53	.402656	8.85	.597344	49
.389711	8.32	.986523	.53	.403187	8.85	.596813	48
.390210	8.30	.986491	.53	.403718	8.85	.596282	47
.390708	8.30	.986459	.53	.404249	8.82	.595751	46
.391206	8.28	9.986427	.53	9.404778	8.83	0.595222	45
.391703	8.27	.986395	.53	.405308	8.80	.594692	44
.392199	8.27	.986363	.53	.405836	8.80	.594164	43
.392695	8.27	.986331	.53	.406364	8.80	.593636	42
.393191	8.23	.986299	.55	.406892	8.78	.593108	41
.393685	8.23	9.986266	.53	9.407419	8.77	0.592581	40
.394179	8.23	.986234	.53	.407945	8.77	.592055	39
.394673	8.22	.986202	.55	.408471	8.75	.591529	38
.395166	8.20	.986169	.53	.408996	8.75	.591004	37
.395658	8.20	.986137	.55	.409521	8.73	.590479	36
.396150	8.18	9.986104	.53	9.410045	8.73	0.589955	35
.396641	8.18	.986072	.55	.410569	8.72	.589431	34
.397132	8.15	.986039	.53	.411092	8.72	.588908	33
.397621	8.17	.986007	.55	.411615	8.70	.588385	32
.398111	8.15	.985974	.53	.412137	8.68	.587863	31
.398600	8.13	9.985942	.55	9.412658	8.68	0.587342	30
.399088	8.12	.985909	.55	.413179	8.67	.586821	29
.399575	8.12	.985876	.55	.413699	8.67	.586301	28
.400062	8.12	.985843	.53	.414219	8.65	.585781	27
.400549	8.10	.985811	.55	.414738	8.65	.585262	26
.401035	8.08	9.985778	.55	9.415257	8.63	0.584743	25
.401520	8.08	.985745	.55	.415775	8.63	.584225	24
.402005	8.07	.985712	.55	.416293	8.62	.583707	23
.402489	8.05	.985679	.55	.416810	8.60	.583190	22
.402972	8.05	.985646	.55	.417326	8.60	.582674	21
.403455	8.05	9.985613	.55	9.417842	8.60	0.582158	20
.403938	8.03	.985580	.55	.418358	8.58	.581642	19
.404420	8.02	.985547	.55	.418873	8.57	.581127	18
.404901	8.02	.985514	.57	.419387	8.57	.580613	17
.405382	8.00	.985480	.55	.419901	8.57	.580099	16
.405862	7.98	9.985447	.55	9.420415	8.53	0.579585	15
.406341	7.98	.985414	.55	.420927	8.55	.579073	14
.406820	7.98	.985381	.57	.421440	8.53	.578560	13
.407299	7.97	.985347	.55	.421952	8.52	.578048	12
.407777	7.95	.985314	.57	.422463	8.52	.577537	11
.408254	7.95	9.985280	.55	9.422974	8.50	0.577026	10
.408731	7.93	.985247	.57	.423484	8.48	.576516	9
.409207	7.92	.985213	.55	.423993	8.50	.576007	8
.409682	7.92	.985180	.57	.424503	8.47	.575497	7
.410157	7.92	.985146	.57	.425011	8.47	.574989	6
.410632	7.90	9.985113	.55	9.425519	8.47	0.574481	5
.411106	7.88	.985079	.57	.426027	8.45	.573973	4
.411579	7.88	.985045	.57	.426534	8.45	.573466	3
.412052	7.87	.985011	.55	.427041	8.43	.572959	2
.412524	7.87	.984978	.57	.427547	8.42	.572453	1
.412996		9.984944		9.428052		0.571948	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.
0	9.412996	7.85	9.984944	.57	9.428052	8.43	0.571
1	.413467	7.85	.984910	.57	.428558	8.40	.571
2	.413938	7.83	.984876	.57	.429062	8.40	.570
3	.414408	7.83	.984842	.57	.429566	8.40	.570
4	.414878	7.82	.984808	.57	.430070	8.38	.569
5	9.415347	7.80	9.984774	.57	9.430573	8.37	0.569
6	.415815	7.80	.984740	.57	.431075	8.37	.568
7	.416283	7.80	.984706	.57	.431577	8.37	.568
8	.416751	7.77	.984672	.57	.432079	8.35	.567
9	.417217	7.78	.984638	.58	.432580	8.33	.567
10	9.417684	7.77	9.984603	.57	9.433080	8.33	0.566
11	.418150	7.75	.984569	.57	.433580	8.33	.566
12	.418615	7.73	.984535	.58	.434080	8.32	.565
13	.419079	7.75	.984500	.57	.434579	8.32	.565
14	.419544	7.72	.984466	.57	.435078	8.30	.564
15	9.420007	7.72	9.984432	.58	9.435576	8.28	0.564
16	.420470	7.72	.984397	.57	.436073	8.28	.563
17	.420933	7.70	.984363	.58	.436570	8.28	.563
18	.421395	7.70	.984328	.57	.437067	8.27	.562
19	.421857	7.68	.984294	.58	.437563	8.27	.562
20	9.422318	7.67	9.984259	.58	9.438059	8.25	0.561
21	.422778	7.67	.984224	.57	.438554	8.23	.561
22	.423238	7.65	.934190	.58	.439048	8.25	.560
23	.423697	7.65	.984155	.58	.439543	8.22	.560
24	.424156	7.65	.984120	.58	.440036	8.22	.559
25	9.424615	7.63	9.984085	.58	9.440529	8.22	0.559
26	.425073	7.62	.984050	.58	.441022	8.20	.558
27	.425530	7.62	.984015	.57	.441514	8.20	.558
28	.425987	7.60	.983981	.58	.442006	8.18	.557
29	.426443	7.60	.983946	.58	.442497	8.18	.557
30	9.426899	7.58	9.983911	.60	9.442988	8.18	0.557
31	.427354	7.58	.983875	.58	.443479	8.15	.556
32	.427809	7.57	.983840	.58	.443968	8.17	.556
33	.428263	7.57	.983805	.58	.444458	8.15	.555
34	.428717	7.55	.983770	.58	.444947	8.13	.555
35	9.429170	7.55	9.983735	.58	9.445435	8.13	0.554
36	.429623	7.53	.983700	.60	.445923	8.13	.554
37	.430075	7.53	.983664	.58	.446411	8.12	.553
38	.430527	7.52	.983629	.58	.446898	8.10	.553
39	.430978	7.52	.983594	.60	.447384	8.10	.552
40	9.431429	7.50	9.983558	.58	9.447870	8.10	0.552
41	.431879	7.50	.983523	.60	.448356	8.08	.551
42	.432329	7.48	.983487	.58	.448841	8.08	.551
43	.432778	7.47	.983452	.60	.449326	8.07	.550
44	.433226	7.48	.983416	.58	.449810	8.07	.550
45	9.433675	7.45	9.983381	.60	9.450294	8.05	0.549
46	.434122	7.45	.983345	.60	.450777	8.05	.549
47	.434569	7.45	.983309	.60	.451260	8.05	.548
48	.435016	7.43	.983273	.58	.451743	8.03	.548
49	.435462	7.43	.983238	.60	.452225	8.02	.547
50	9.435908	7.42	9.983202	.60	9.452706	8.02	0.547
51	.436353	7.42	.983166	.60	.453187	8.02	.546
52	.436798	7.40	.983130	.60	.453668	8.00	.546
53	.437242	7.40	.983094	.60	.454148	8.00	.545
54	.437686	7.38	.983058	.60	.454628	7.98	.545
55	9.438129	7.38	9.983022	.60	9.455107	7.98	0.544
56	.438572	7.37	.982986	.60	.455586	7.97	.544
57	.439014	7.37	.982950	.60	.456064	7.97	.543
58	.439456	7.35	.982914	.60	.456542	7.95	.543
59	.439897	7.35	.982878	.60	.457019	7.95	.542
60	9.440338		9.982842		9.457496		0.542
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
440338	7.33	9.982842	.62	9.457496	7.95	0.542504	60
440778	7.33	.982805	.60	.457973	7.93	.542027	59
441218	7.33	.982769	.60	.458449	7.93	.541551	58
441658	7.30	.982733	.62	.458925	7.92	.541075	57
442096	7.32	.982696	.60	.459400	7.92	.540600	56
442535	7.30	9.982660	.60	9.459875	7.90	0.540125	55
442973	7.28	.982624	.62	.460349	7.90	.539651	54
443410	7.28	.982587	.60	.460823	7.90	.539177	53
443847	7.28	.982551	.62	.461297	7.88	.538703	52
444284	7.27	.982514	.62	.461770	7.87	.538230	51
444720	7.25	9.982477	.60	9.462242	7.88	0.537758	50
445155	7.25	.982441	.62	.462715	7.85	.537285	49
445590	7.25	.982404	.62	.463186	7.87	.536814	48
446025	7.23	.982367	.60	.463658	7.83	.536342	47
446459	7.23	.982331	.62	.464128	7.85	.535872	46
446893	7.22	9.982294	.62	9.464599	7.83	0.535401	45
447326	7.22	.982257	.62	.465069	7.83	.534931	44
447759	7.20	.982220	.62	.465539	7.82	.534461	43
448191	7.20	.982183	.62	.466008	7.82	.533992	42
448623	7.18	.982146	.62	.466477	7.80	.533523	41
449054	7.18	9.982109	.62	9.466945	7.80	0.533055	40
449485	7.17	.982072	.62	.467413	7.78	.532587	39
449915	7.17	.982035	.62	.467880	7.78	.532120	38
450345	7.17	.981998	.62	.468347	7.78	.531653	37
450775	7.15	.981961	.62	.468814	7.77	.531186	36
451204	7.13	9.981924	.63	9.469280	7.77	0.530720	35
451632	7.13	.981886	.62	.469746	7.75	.530254	34
452060	7.13	.981849	.62	.470211	7.75	.529789	33
452488	7.12	.981812	.63	.470676	7.75	.529324	32
452915	7.12	.981774	.62	.471141	7.73	.528859	31
453342	7.10	9.981737	.62	9.471605	7.73	0.528395	30
453768	7.10	.981700	.63	.472069	7.72	.527931	29
454194	7.08	.981662	.62	.472532	7.72	.527468	28
454619	7.08	.981625	.63	.472995	7.70	.527005	27
455044	7.08	.981587	.63	.473457	7.70	.526543	26
455469	7.07	9.981549	.62	9.473919	7.70	0.526081	25
455893	7.05	.981512	.63	.474381	7.68	.525619	24
456316	7.05	.981474	.63	.474842	7.68	.525158	23
456739	7.05	.981436	.62	.475303	7.67	.524697	22
457162	7.03	.981399	.63	.475763	7.67	.524237	21
457584	7.03	9.981361	.63	9.476223	7.67	0.523777	20
458006	7.02	.981323	.63	.476683	7.65	.523317	19
458427	7.02	.981285	.63	.477142	7.65	.522858	18
458848	7.00	.981247	.63	.477601	7.63	.522399	17
459268	7.00	.981209	.63	.478059	7.63	.521941	16
459688	7.00	9.981171	.63	9.478517	7.63	0.521483	15
460108	6.98	.981133	.63	.478975	7.62	.521025	14
460527	6.98	.981095	.63	.479432	7.62	.520568	13
460946	6.97	.981057	.63	.479889	7.60	.520111	12
461364	6.97	.981019	.63	.480345	7.60	.519655	11
461782	6.95	9.980981	.65	9.480801	7.60	0.519199	10
462199	6.95	.980942	.63	.481257	7.58	.518743	9
462616	6.93	.980904	.63	.481712	7.58	.518288	8
463032	6.93	.980866	.65	.482167	7.57	.517833	7
463448	6.93	.980827	.63	.482621	7.57	.517379	6
463864	6.92	9.980789	.65	9.483075	7.57	0.516925	5
464279	6.92	.980750	.63	.483529	7.55	.516471	4
464694	6.90	.980712	.65	.483982	7.55	.516018	3
465108	6.90	.980673	.63	.484435	7.53	.515565	2
465522	6.88	.980635	.65	.484887	7.53	.515113	1
465935		9.980596		9.485339		0.514661	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

73°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.465935	6.88	9.980596	.63	9.485339	7.53	
1	.466348	6.88	.980558	.65	.485791	7.52	
2	.466761	6.87	.980519	.65	.486242	7.52	
3	.467173	6.87	.980480	.63	.486693	7.50	
4	.467585	6.85	.980442	.65	.487143	7.50	
5	9.467996	6.85	9.980403	.65	9.487593	7.50	
6	.468407	6.83	.980364	.65	.488043	7.48	
7	.468817	6.83	.980325	.65	.488492	7.48	
8	.469227	6.83	.980286	.65	.488941	7.48	
9	.469637	6.82	.980247	.65	.489390	7.47	
10	9.470046	6.82	9.980208	.65	9.489838	7.47	
11	.470455	6.80	.980169	.65	.490286	7.45	
12	.470863	6.80	.980130	.65	.490733	7.45	
13	.471271	6.80	.980091	.65	.491180	7.45	
14	.471679	6.78	.980052	.67	.491627	7.43	
15	9.472086	6.77	9.980012	.65	9.492073	7.43	0
16	.472492	6.77	.979973	.65	.492519	7.43	.
17	.472898	6.77	.979934	.65	.492965	7.42	.
18	.473304	6.77	.979895	.67	.493410	7.40	.
19	.473710	6.75	.979855	.65	.493854	7.42	.
20	9.474115	6.73	9.979816	.67	9.494299	7.40	0.
21	.474519	6.73	.979776	.65	.494743	7.38	.
22	.474923	6.73	.979737	.67	.495186	7.40	.
23	.475327	6.72	.979697	.65	.495630	7.38	.5
24	.475730	6.72	.979658	.67	.496073	7.37	.5
25	9.476133	6.72	9.979618	.65	9.496515	7.37	0.5
26	.476536	6.70	.979579	.67	.496957	7.37	.5
27	.476938	6.70	.979539	.67	.497399	7.37	.5
28	.477340	6.68	.979499	.67	.497841	7.35	.5
29	.477741	6.68	.979459	.65	.498282	7.33	.5
30	9.478142	6.67	9.979420	.67	9.498722	7.35	0.5
31	.478542	6.67	.979380	.67	.499163	7.33	.5
32	.478942	6.67	.979340	.67	.499603	7.32	.5
33	.479342	6.65	.979300	.67	.500042	7.32	.49
34	.479741	6.65	.979260	.67	.500481	7.32	.49
35	9.480140	6.65	9.979220	.67	9.500920	7.32	0.49
36	.480539	6.63	.979180	.67	.501359	7.30	.49
37	.480937	6.62	.979140	.67	.501797	7.30	.49
38	.481334	6.62	.979100	.68	.502235	7.28	.49
39	.481731	6.62	.979059	.67	.502672	7.28	.49
40	9.482128	6.62	9.979019	.67	9.503109	7.28	0.49
41	.482525	6.60	.978979	.67	.503546	7.27	.49
42	.482921	6.58	.978939	.68	.503982	7.27	.49
43	.483316	6.60	.978898	.67	.504418	7.27	.49
44	.483712	6.58	.978858	.68	.504854	7.25	.49
45	9.484107	6.57	9.978817	.67	9.505289	7.25	0.49
46	.484501	6.57	.978777	.67	.505724	7.25	.49
47	.484895	6.57	.978737	.68	.506159	7.23	.49
48	.485289	6.55	.978696	.68	.506593	7.23	.49
49	.485682	6.55	.978655	.67	.507027	7.22	.49
50	9.486075	6.53	9.978615	.68	9.507460	7.22	0.49
51	.486467	6.55	.978574	.68	.507893	7.22	.49
52	.486860	6.52	.978533	.67	.508326	7.22	.49
53	.487251	6.53	.978493	.68	.508759	7.20	.49
54	.487643	6.52	.978452	.68	.509191	7.18	.49
55	9.488034	6.50	9.978411	.68	9.509622	7.20	0.49
56	.488424	6.50	.978370	.68	.510054	7.18	.48
57	.488814	6.50	.978329	.68	.510485	7.18	.48
58	.489204	6.48	.978288	.68	.510916	7.17	.48
59	.489593	6.48	.978247	.68	.511346	7.17	.48
60	9.489982		9.978206		9.511776		0.48
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan

in.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9982	6.48	9.978206	.68	9.511776	7.17	0.488224	60
0371	6.47	.978165	.68	.512206	7.15	.487794	59
0759	6.47	.978124	.68	.512635	7.15	.487365	58
1147	6.47	.978083	.68	.513064	7.15	.486936	57
1535	6.45	.978042	.68	.513493	7.13	.486507	56
1922	6.43	9.978001	.70	9.513921	7.13	0.486079	55
2308	6.45	.977959	.68	.514349	7.13	.485651	54
2695	6.43	.977918	.68	.514777	7.12	.485223	53
3081	6.42	.977877	.70	.515204	7.12	.484796	52
3466	6.42	.977835	.68	.515631	7.10	.484369	51
3851	6.42	9.977794	.70	9.516057	7.12	0.483943	50
4236	6.42	.977752	.68	.516484	7.10	.483516	49
4621	6.40	.977711	.70	.516910	7.08	.483090	48
5005	6.38	.977669	.68	.517335	7.10	.482665	47
5388	6.40	.977628	.70	.517761	7.08	.482239	46
5772	6.37	9.977586	.70	9.518186	7.07	0.481814	45
6154	6.38	.977544	.68	.518610	7.07	.481390	44
6537	6.37	.977503	.70	.519034	7.07	.480966	43
6919	6.37	.977461	.70	.519458	7.07	.480542	42
7301	6.35	.977419	.70	.519882	7.05	.480118	41
7682	6.37	9.977377	.70	9.520305	7.05	0.479695	40
8064	6.33	.977335	.70	.520728	7.05	.479272	39
8444	6.35	.977293	.70	.521151	7.03	.478849	38
8825	6.32	.977251	.70	.521573	7.03	.478427	37
9204	6.33	.977209	.70	.521995	7.03	.478005	36
9584	6.32	9.977167	.70	9.522417	7.02	0.477583	35
9963	6.32	.977125	.70	.522838	7.02	.477162	34
0342	6.32	.977083	.70	.523259	7.02	.476741	33
0721	6.30	.977041	.70	.523680	7.00	.476320	32
1099	6.28	.976999	.70	.524100	7.00	.475900	31
1476	6.30	9.976957	.72	9.524520	7.00	0.475480	30
1854	6.28	.976914	.70	.524940	6.98	.475060	29
2231	6.27	.976872	.70	.525359	6.98	.474641	28
2607	6.28	.976830	.72	.525778	6.98	.474222	27
2984	6.27	.976787	.70	.526197	6.97	.473803	26
3360	6.25	9.976745	.72	9.526615	6.97	0.473385	25
3735	6.25	.976702	.70	.527033	6.97	.472967	24
4110	6.25	.976660	.72	.527451	6.95	.472549	23
4485	6.25	.976617	.72	.527868	6.95	.472132	22
4860	6.23	.976574	.70	.528285	6.95	.471715	21
5234	6.23	9.976532	.72	9.528702	6.95	0.471298	20
5608	6.22	.976489	.72	.529119	6.93	.470881	19
5981	6.22	.976446	.70	.529535	6.93	.470465	18
6354	6.22	.976404	.72	.529951	6.92	.470049	17
6727	6.20	.976361	.72	.530366	6.92	.469634	16
7099	6.20	9.976318	.72	9.530781	6.92	0.469219	15
7471	6.20	.976275	.72	.531196	6.92	.468804	14
7843	6.18	.976232	.72	.531611	6.90	.468389	13
8214	6.18	.976189	.72	.532025	6.90	.467975	12
8585	6.18	.976146	.72	.532439	6.90	.467561	11
	6.17	9.976103	.72	9.532853	6.88	0.467147	10
	6.17	.976060	.72	.533266	6.88	.466734	9
	6.15	.976017	.72	.533679	6.88	.466321	8
	6.15	.975974	.73	.534092	6.87	.465908	7
	6.15	.975930	.72	.534504	6.87	.465496	6
	6.15	9.975887	.72	9.534916	6.87	0.465084	5
	6.13	.975844	.73	.535328	6.85	.464672	4
	6.12	.975800	.72	.535739	6.85	.464261	3
	6.13	.975757	.72	.536150	6.85	.463850	2
	6.12	.975714	.73	.536561	6.85	.463439	1
		9.975670		9.536972		0.463028	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.
0	9.512642	6.12	9.975670	.72	9.536972	6.83
1	.513009	6.10	.975627	.73	.537382	6.83
2	.513375	6.10	.975583	.73	.537792	6.83
3	.513741	6.10	.975539	.72	.538202	6.82
4	.514107	6.08	.975496	.73	.538611	6.82
5	9.514472	6.08	9.975452	.73	9.539020	6.82
6	.514837	6.08	.975408	.72	.539429	6.80
7	.515202	6.07	.975365	.73	.539837	6.80
8	.515566	6.07	.975321	.73	.540245	6.80
9	.515930	6.07	.975277	.73	.540653	6.80
10	9.516294	6.05	9.975233	.73	9.541061	6.78
11	.516657	6.05	.975189	.73	.541468	6.78
12	.517020	6.03	.975145	.73	.541875	6.77
13	.517382	6.05	.975101	.73	.542281	6.78
14	.517745	6.03	.975057	.73	.542688	6.77
15	9.518107	6.02	9.975013	.73	9.543094	6.75
16	.518468	6.02	.974969	.73	.543499	6.77
17	.518829	6.02	.974925	.75	.543905	6.75
18	.519190	6.02	.974880	.73	.544310	6.75
19	.519551	6.00	.974836	.73	.544715	6.73
20	9.519911	6.00	9.974792	.73	9.545119	6.75
21	.520271	6.00	.974748	.75	.545524	6.73
22	.520631	5.98	.974703	.73	.545928	6.72
23	.520990	5.98	.974659	.75	.546331	6.73
24	.521349	5.97	.974614	.73	.546735	6.72
25	9.521707	5.98	9.974570	.75	9.547138	6.70
26	.522066	5.97	.974525	.73	.547540	6.72
27	.522424	5.95	.974481	.75	.547943	6.70
28	.522781	5.95	.974436	.75	.548345	6.70
29	.523138	5.95	.974391	.73	.548747	6.70
30	9.523495	5.95	9.974347	.75	9.549149	6.68
31	.523852	5.93	.974302	.75	.549550	6.68
32	.524208	5.93	.974257	.75	.549951	6.68
33	.524564	5.93	.974212	.75	.550352	6.67
34	.524920	5.92	.974167	.75	.550752	6.68
35	9.525275	5.92	9.974122	.75	9.551153	6.65
36	.525630	5.90	.974077	.75	.551552	6.67
37	.525984	5.92	.974032	.75	.551952	6.65
38	.526339	5.90	.973987	.75	.552351	6.65
39	.526693	5.88	.973942	.75	.552750	6.65
40	9.527046	5.90	9.973897	.75	9.553149	6.65
41	.527400	5.88	.973852	.75	.553548	6.63
42	.527753	5.87	.973807	.77	.553946	6.63
43	.528105	5.88	.973761	.75	.554344	6.62
44	.528458	5.87	.973716	.75	.554741	6.63
45	9.528810	5.85	9.973671	.77	9.555139	6.62
46	.529161	5.87	.973625	.75	.555536	6.62
47	.529513	5.85	.973580	.75	.555933	6.60
48	.529864	5.85	.973535	.77	.556329	6.60
49	.530215	5.83	.973489	.75	.556725	6.60
50	9.530565	5.83	9.973444	.77	9.557121	6.60
51	.530915	5.83	.973398	.77	.557517	6.60
52	.531265	5.82	.973352	.75	.557913	6.58
53	.531614	5.82	.973307	.77	.558308	6.58
54	.531963	5.82	.973261	.77	.558703	6.57
55	9.532312	5.82	9.973215	.77	9.559097	6.57
56	.532661	5.80	.973169	.75	.559491	6.57
57	.533009	5.80	.973124	.77	.559885	6.57
58	.533357	5.78	.973078	.77	.560279	6.57
59	.533704	5.80	.973032	.77	.560673	6.55
60	9.534052		9.972986		9.561066	
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.

109°

n.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
4052	5.78	9.972986	.77	9.561066	6.55	0.438934	60
4399	5.77	.972940	.77	.561459	6.53	.438541	59
4745	5.78	.972894	.77	.561851	6.55	.438149	58
5092	5.77	.972848	.77	.562244	6.53	.437756	57
5438	5.75	.972802	.78	.562636	6.53	.437364	56
5783	5.77	9.972755	.77	9.563028	6.52	0.436972	55
6129	5.75	.972709	.77	.563419	6.53	.436581	54
6474	5.73	.972663	.77	.563811	6.52	.436189	53
6818	5.75	.972617	.78	.564202	6.52	.435798	52
7163	5.73	.972570	.77	.564593	6.50	.435407	51
7507	5.73	9.972524	.77	9.564983	6.50	0.435017	50
7851	5.72	.972478	.78	.565373	6.50	.434627	49
8194	5.73	.972431	.77	.565763	6.50	.434237	48
8538	5.70	.972385	.78	.566153	6.48	.433847	47
8880	5.72	.972338	.78	.566542	6.50	.433458	46
9223	5.70	9.972291	.77	9.566932	6.47	0.433068	45
9565	5.70	.972245	.78	.567320	6.48	.432680	44
9907	5.70	.972198	.78	.567709	6.48	.432291	43
0249	5.68	.972151	.77	.568098	6.47	.431902	42
0590	5.68	.972105	.78	.568486	6.45	.431514	41
0931	5.68	9.972058	.78	9.568873	6.47	0.431127	40
1272	5.68	.972011	.78	.569261	6.45	.430739	39
1613	5.67	.971964	.78	.569648	6.45	.430352	38
1953	5.67	.971917	.78	.570035	6.45	.429965	37
2293	5.65	.971870	.78	.570422	6.45	.429578	36
2632	5.65	9.971823	.78	9.570809	6.43	0.429191	35
2971	5.65	.971776	.78	.571195	6.43	.428805	34
3310	5.65	.971729	.78	.571581	6.43	.428419	33
3649	5.63	.971682	.78	.571967	6.42	.428033	32
3987	5.63	.971635	.78	.572352	6.43	.427648	31
4325	5.63	9.971588	.80	9.572738	6.42	0.427262	30
4663	5.62	.971540	.78	.573123	6.40	.426877	29
5000	5.63	.971493	.78	.573507	6.42	.426493	28
5338	5.60	.971446	.80	.573892	6.40	.426108	27
5674	5.62	.971398	.78	.574276	6.40	.425724	26
6011	5.60	9.971351	.80	9.574660	6.40	0.425340	25
6347	5.60	.971303	.78	.575044	6.38	.424956	24
6683	5.60	.971256	.80	.575427	6.38	.424573	23
7019	5.58	.971208	.78	.575810	6.38	.424190	22
7354	5.58	.971161	.80	.576193	6.38	.423807	21
7689	5.58	9.971113	.78	9.576576	6.38	0.423424	20
8024	5.58	.971066	.80	.576959	6.37	.423041	19
8359	5.57	.971018	.80	.577341	6.37	.422659	18
8693	5.57	.970970	.80	.577723	6.35	.422277	17
9027	5.55	.970922	.80	.578104	6.37	.421896	16
9360	5.55	9.970874	.78	9.578486	6.35	0.421514	15
9693	5.55	.970827	.80	.578867	6.35	.421133	14
0026	5.55	.970779	.80	.579248	6.35	.420752	13
0359	5.55	.970731	.80	.579629	6.33	.420371	12
0692	5.53	.970683	.80	.580009	6.33	.419991	11
1024	5.53	9.970635	.82	9.580389	6.33	0.419611	10
1356	5.52	.970586	.80	.580769	6.33	.419231	9
1687	5.52	.970538	.80	.581149	6.32	.418851	8
2018	5.52	.970490	.80	.581528	6.32	.418472	7
2349	5.52	.970442	.80	.581907	6.32	.418093	6
2680	5.50	9.970394	.82	9.582286	6.32	0.417714	5
3010	5.52	.970345	.80	.582665	6.32	.417335	4
3341	5.48	.970297	.80	.583044	6.30	.416956	3
3670	5.50	.970249	.82	.583422	6.30	.416578	2
4000	5.48	.970200	.80	.583800	6.28	.416200	1
4329		9.970152		9.584177		0.415823	0
os.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

69°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	C
0	9.554329	5.48	9.970152	.82	9.584177	6.30	0.
1	.554658	5.48	.970103	.80	.584555	6.28	.
2	.554987	5.47	.970055	.82	.584932	6.28	.
3	.555315	5.47	.970006	.82	.585309	6.28	.
4	.555643	5.47	.969957	.80	.585686	6.27	.
5	9.555971	5.47	9.969909	.82	9.586062	6.28	0
6	.556299	5.45	.969860	.82	.586439	6.27	
7	.556626	5.45	.969811	.82	.586815	6.25	
8	.556953	5.45	.969762	.80	.587190	6.27	
9	.557280	5.43	.969714	.82	.587566	6.25	
10	9.557606	5.43	9.969665	.82	9.587941	6.25	0
11	.557932	5.43	.969616	.82	.588316	6.25	
12	.558258	5.42	.969567	.82	.588691	6.25	
13	.558583	5.43	.969518	.82	.589066	6.23	
14	.558909	5.42	.969469	.82	.589440	6.23	
15	9.559234	5.40	9.969420	.83	9.589814	6.23	0
16	.559558	5.42	.969370	.82	.590188	6.23	
17	.559883	5.40	.969321	.82	.590562	6.22	
18	.560207	5.40	.969272	.82	.590935	6.22	
19	.560531	5.40	.969223	.83	.591308	6.22	
20	9.560855	5.38	9.969173	.82	9.591681	6.22	0
21	.561178	5.38	.969124	.82	.592054	6.20	
22	.561501	5.38	.969075	.83	.592426	6.22	
23	.561824	5.37	.969025	.82	.592799	6.20	
24	.562146	5.37	.968976	.83	.593171	6.18	
25	9.562468	5.37	9.968926	.82	9.593542	6.20	0
26	.562790	5.37	.968877	.83	.593914	6.18	
27	.563112	5.35	.968827	.83	.594285	6.18	
28	.563433	5.37	.968777	.82	.594656	6.18	
29	.563755	5.33	.968728	.83	.595027	6.18	
30	9.564075	5.35	9.968678	.83	9.595398	6.17	0
31	.564396	5.33	.968628	.83	.595768	6.17	
32	.564716	5.33	.968578	.83	.596138	6.17	
33	.565036	5.33	.968528	.82	.596508	6.17	
34	.565356	5.33	.968479	.83	.596878	6.15	
35	9.565676	5.32	9.968429	.83	9.597247	6.15	0
36	.565995	5.32	.968379	.83	.597616	6.15	
37	.566314	5.30	.968329	.85	.597985	6.15	
38	.566632	5.32	.968278	.83	.598354	6.13	
39	.566951	5.30	.968228	.83	.598722	6.15	
40	9.567269	5.30	9.968178	.83	9.599091	6.13	0
41	.567587	5.28	.968128	.83	.599459	6.13	
42	.567904	5.30	.968078	.85	.599827	6.12	
43	.568222	5.28	.968027	.83	.600194	6.13	
44	.568539	5.28	.967977	.83	.600562	6.12	
45	9.568856	5.27	9.967927	.85	9.600929	6.12	0
46	.569172	5.27	.967876	.83	.601296	6.12	
47	.569488	5.27	.967826	.85	.601663	6.10	
48	.569804	5.27	.967775	.83	.602029	6.10	
49	.570120	5.25	.967725	.85	.602395	6.10	
50	9.570435	5.27	9.967674	.83	9.602761	6.10	0
51	.570751	5.25	.967624	.85	.603127	6.10	
52	.571066	5.23	.967573	.85	.603493	6.08	
53	.571380	5.25	.967522	.85	.603858	6.08	
54	.571695	5.23	.967471	.83	.604223	6.08	
55	9.572009	5.23	9.967421	.85	9.604588	6.08	0
56	.572323	5.22	.967370	.85	.604953	6.07	
57	.572636	5.23	.967319	.85	.605317	6.08	
58	.572950	5.22	.967268	.85	.605682	6.07	
59	.573263	5.20	.967217	.85	.606046	6.07	
60	9.573575		9.967166		9.606410		0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.573575	5.22	9.967166	.85	9.606410	6.05	0.393590	60
.573888	5.20	.967115	.85	.606773	6.07	.393227	59
.574200	5.20	.967064	.85	.607137	6.05	.392863	58
.574512	5.20	.967013	.87	.607500	6.05	.392500	57
.574824	5.20	.966961	.85	.607863	6.03	.392137	56
9.575136	5.18	9.966910	.85	9.608225	6.05	0.391775	55
.575447	5.18	.966859	.85	.608588	6.03	.391412	54
.575758	5.18	.966808	.87	.608950	6.03	.391050	53
.576069	5.17	.966756	.85	.609312	6.03	.390688	52
.576379	5.17	.966705	.87	.609674	6.03	.390326	51
9.576689	5.17	9.966653	.85	9.610036	6.02	0.389964	50
.576999	5.17	.966602	.87	.610397	6.03	.389603	49
.577309	5.15	.966550	.85	.610759	6.02	.389241	48
.577618	5.15	.966499	.87	.611120	6.00	.388880	47
.577927	5.15	.966447	.87	.611480	6.02	.388520	46
9.578236	5.15	9.966395	.85	9.611841	6.00	0.388159	45
.578545	5.13	.966344	.87	.612201	6.00	.387799	44
.578853	5.15	.966292	.87	.612561	6.00	.387439	43
.579162	5.13	.966240	.87	.612921	6.00	.387079	42
.579470	5.12	.966188	.87	.613281	6.00	.386719	41
9.579777	5.13	9.966136	.85	9.613641	5.98	0.386359	40
.580085	5.12	.966085	.87	.614000	5.98	.386000	39
.580392	5.12	.966033	.87	.614359	5.98	.385641	38
.580699	5.10	.965981	.87	.614718	5.98	.385282	37
.581005	5.12	.965929	.88	.615077	5.97	.384923	36
9.581312	5.10	9.965876	.87	9.615435	5.97	0.384565	35
.581618	5.10	.965824	.87	.615793	5.97	.384207	34
.581924	5.08	.965772	.87	.616151	5.97	.383849	33
.582229	5.10	.965720	.87	.616509	5.97	.383491	32
.582535	5.08	.965668	.88	.616867	5.95	.383133	31
9.582840	5.08	9.965615	.87	9.617224	5.97	0.382776	30
.583145	5.07	.965563	.87	.617582	5.95	.382418	29
.583449	5.08	.965511	.88	.617939	5.93	.382061	28
.583754	5.07	.965458	.87	.618295	5.95	.381705	27
.584058	5.05	.965406	.88	.618652	5.93	.381348	26
9.584361	5.07	9.965353	.87	9.619008	5.93	0.380992	25
.584665	5.05	.965301	.88	.619364	5.93	.380636	24
.584968	5.07	.965248	.88	.619720	5.93	.380280	23
.585272	5.03	.965195	.87	.620076	5.93	.379924	22
.585574	5.05	.965143	.88	.620432	5.92	.379568	21
9.585877	5.03	9.965090	.88	9.620787	5.92	0.379213	20
.586179	5.05	.965037	.88	.621142	5.92	.378858	19
.586482	5.02	.964984	.88	.621497	5.92	.378503	18
.586783	5.03	.964931	.87	.621852	5.92	.378148	17
.587085	5.02	.964879	.88	.622207	5.90	.377793	16
9.587386	5.03	9.964826	.88	9.622561	5.90	0.377439	15
.587688	5.02	.964773	.88	.622915	5.90	.377085	14
.587989	5.00	.964720	.90	.623269	5.90	.376731	13
.588289	5.02	.964666	.88	.623623	5.88	.376377	12
.588590	5.00	.964613	.88	.623976	5.90	.376024	11
9.588890	5.00	9.964560	.88	9.624330	5.88	0.375670	10
.589190	4.98	.964507	.88	.624683	5.88	.375317	9
.589489	5.00	.964454	.90	.625036	5.87	.374964	8
.589789	4.98	.964400	.88	.625388	5.88	.374612	7
.590088	4.98	.964347	.88	.625741	5.87	.374259	6
9.590387	4.98	9.964294	.90	9.626093	5.87	0.373907	5
.590686	4.97	.964240	.88	.626445	5.87	.373555	4
.590984	4.97	.964187	.90	.626797	5.87	.373203	3
.591282	4.97	.964133	.88	.627149	5.87	.372851	2
.591580	4.97	.964080	.90	.627501	5.85	.372499	1
9.591878		9.964026		9.627852		0.372148	0
Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.591878		9.964026		9.627852		C
1	.592176	4.97	.963972	.90	.628203	5.85	
2	.592473	4.95	.963919	.88	.628554	5.85	
3	.592770	4.95	.963865	.90	.628905	5.85	
4	.593067	4.95	.963811	.90	.629255	5.83	
5	9.593363	4.93	9.963757	.90	9.629606	5.85	
6	.593659	4.93	.963704	.88	.629956	5.83	C
7	.593955	4.93	.963650	.90	.630306	5.83	
8	.594251	4.93	.963596	.90	.630656	5.83	
9	.594547	4.93	.963542	.90	.631005	5.82	
10	9.594842	4.92	9.963488	.90	9.631355	5.83	C
11	.595137	4.92	.963434	.90	.631704	5.82	
12	.595432	4.92	.963379	.92	.632053	5.82	
13	.595727	4.90	.963325	.90	.632402	5.82	
14	.596021	4.90	.963271	.90	.632750	5.80	
15	9.596315	4.90	9.963217	.90	9.633099	5.82	C
16	.596609	4.90	.963163	.92	.633447	5.80	
17	.596903	4.88	.963108	.90	.633795	5.80	
18	.597196	4.90	.963054	.92	.634143	5.80	
19	.597490	4.88	.962999	.90	.634490	5.78	
20	9.597783	4.87	9.962945	.92	9.634838	5.80	C
21	.598075	4.88	.962890	.90	.635185	5.78	
22	.598368	4.87	.962836	.92	.635532	5.78	
23	.598660	4.87	.962781	.90	.635879	5.78	
24	.598952	4.87	.962727	.92	.636226	5.78	
25	9.599244	4.87	9.962672	.92	9.636572	5.77	C
26	.599536	4.85	.962617	.92	.636919	5.78	
27	.599827	4.85	.962562	.90	.637265	5.77	
28	.600118	4.85	.962508	.92	.637611	5.77	
29	.600409	4.85	.962453	.92	.637956	5.75	
30	9.600700	4.83	9.962398	.92	9.638302	5.77	C
31	.600990	4.83	.962343	.92	.638647	5.75	
32	.601280	4.83	.962288	.92	.638992	5.75	
33	.601570	4.83	.962233	.92	.639337	5.75	
34	.601860	4.83	.962178	.92	.639682	5.75	
35	9.602150	4.82	9.962123	.93	9.640027	5.73	C
36	.602439	4.82	.962067	.92	.640371	5.75	
37	.602728	4.82	.962012	.92	.640716	5.73	
38	.603017	4.80	.961957	.92	.641060	5.73	
39	.603305	4.82	.961902	.93	.641404	5.72	
40	9.603594	4.80	9.961846	.92	9.641747	5.73	C
41	.603882	4.80	.961791	.93	.642091	5.72	
42	.604170	4.78	.961735	.92	.642434	5.72	
43	.604457	4.80	.961680	.93	.642777	5.72	
44	.604745	4.78	.961624	.92	.643120	5.72	
45	9.605032	4.78	9.961569	.93	9.643463	5.72	C
46	.605319	4.78	.961513	.92	.643806	5.70	
47	.605606	4.77	.961458	.93	.644148	5.70	
48	.605892	4.78	.961402	.93	.644490	5.70	
49	.606179	4.77	.961346	.93	.644832	5.70	
50	9.606465	4.77	9.961290	.92	9.645174	5.70	C
51	.606751	4.75	.961235	.93	.645516	5.68	
52	.607036	4.77	.961179	.93	.645857	5.70	
53	.607322	4.75	.961123	.93	.646199	5.68	
54	.607607	4.75	.961067	.93	.646540	5.68	
55	9.607892	4.75	9.961011	.93	9.646881	5.68	C
56	.608177	4.73	.960955	.93	.647222	5.67	
57	.608461	4.73	.960899	.93	.647562	5.68	
58	.608745	4.73	.960843	.93	.647903	5.67	
59	.609029	4.73	.960786	.95	.648243	5.67	
60	9.609313		9.960730	.93	9.648583		C
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	

.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
313	4.73	9.960730	.93	9.648583	5.67	0.351417	60
597	4.72	.960674	.93	.648923	5.67	.351077	59
880	4.73	.960618	.95	.649263	5.65	.350737	58
164	4.72	.960561	.93	.649602	5.67	.350398	57
447	4.70	.960505	.95	.649942	5.65	.350058	56
729	4.72	9.960448	.93	9.650281	5.65	0.349719	55
012	4.70	.960392	.95	.650620	5.65	.349380	54
294	4.70	.960335	.93	.650959	5.63	.349041	53
576	4.70	.960279	.95	.651297	5.65	.348703	52
858	4.70	.960222	.95	.651636	5.63	.348364	51
140	4.68	9.960165	.93	9.651974	5.63	0.348026	50
421	4.68	.960109	.95	.652312	5.63	.347688	49
702	4.68	.960052	.95	.652650	5.63	.347350	48
983	4.68	.959995	.95	.652988	5.63	.347012	47
264	4.68	.959938	.93	.653326	5.62	.346674	46
545	4.67	9.959882	.95	9.653663	5.62	0.346337	45
825	4.67	.959825	.95	.654000	5.62	.346000	44
105	4.67	.959768	.95	.654337	5.62	.345663	43
385	4.67	.959711	.95	.654674	5.62	.345326	42
665	4.65	.959654	.97	.655011	5.62	.344989	41
944	4.65	9.959596	.95	9.655348	5.60	0.344652	40
223	4.65	.959539	.95	.655684	5.60	.344316	39
502	4.65	.959482	.95	.656020	5.60	.343980	38
781	4.65	.959425	.95	.656356	5.60	.343644	37
060	4.65	.959368	.97	.656692	5.60	.343308	36
338	4.63	9.959310	.95	9.657028	5.60	0.342972	35
616	4.63	.959253	.97	.657364	5.58	.342636	34
894	4.63	.959195	.95	.657699	5.58	.342301	33
172	4.63	.959138	.97	.658034	5.58	.341966	32
450	4.62	.959080	.95	.658369	5.58	.341631	31
727	4.62	9.959023	.97	9.658704	5.58	0.341296	30
004	4.62	.958965	.95	.659039	5.57	.340961	29
281	4.62	.958908	.97	.659373	5.58	.340627	28
558	4.60	.958850	.97	.659708	5.57	.340292	27
834	4.60	.958792	.97	.660042	5.57	.339958	26
110	4.60	9.958734	.95	9.660376	5.57	0.339624	25
386	4.60	.958677	.97	.660710	5.55	.339290	24
662	4.60	.958619	.97	.661043	5.57	.338957	23
938	4.58	.958561	.97	.661377	5.55	.338623	22
213	4.58	.958503	.97	.661710	5.55	.338290	21
488	4.58	9.958445	.97	9.662043	5.55	0.337957	20
763	4.58	.958387	.97	.662376	5.55	.337624	19
038	4.58	.958329	.97	.662709	5.55	.337291	18
313	4.57	.958271	.97	.663042	5.55	.336958	17
587	4.57	.958213	.98	.663375	5.53	.336625	16
861	4.57	9.958154	.97	9.663707	5.53	0.336293	15
135	4.57	.958096	.97	.664039	5.53	.335961	14
409	4.57	.958038	.98	.664371	5.53	.335629	13
682	4.55	.957979	.97	.664703	5.53	.335297	12
956	4.57	.957921	.97	.665035	5.52	.334965	11
229	4.55	9.957863	.98	9.665366	5.53	0.334634	10
502	4.53	.957804	.97	.665698	5.52	.334302	9
774	4.55	.957746	.98	.666029	5.52	.333971	8
047	4.53	.957687	.98	.666360	5.52	.333640	7
319	4.53	.957628	.97	.666691	5.50	.333309	6
591	4.53	9.957570	.98	9.667021	5.52	0.332979	5
863	4.53	.957511	.98	.667352	5.50	.332648	4
135	4.52	.957452	.98	.667682	5.52	.332318	3
406	4.52	.957393	.97	.668013	5.50	.331987	2
677	4.52	.957335	.98	.668343	5.50	.331657	1
948		9.957276		9.668673	5.50	0.331327	0
ns.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

65°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1′	
0	9.657047	4.13	9.949881	1.08	9.707166	5.2	
1	.657295	4.12	.949816	1.07	.707478	5.2	
2	.657542	4.13	.949752	1.07	.707790	5.2	
3	.657790	4.12	.949688	1.08	.708102	5.2	
4	.658037	4.12	.949623	1.08	.708414	5.2	
5	9.658284	4.12	9.949558	1.07	9.708726	5.1	
6	.658531	4.12	.949494	1.08	.709037	5.2	
7	.658778	4.12	.949429	1.08	.709349	5.1	
8	.659025	4.10	.949364	1.07	.709660	5.1	
9	.659271	4.10	.949300	1.08	.709971	5.1	
10	9.659517	4.10	9.949235	1.08	9.710282	5.1	
11	.659763	4.10	.949170	1.08	.710593	5.1	
12	.660009	4.10	.949105	1.08	.710904	5.1	
13	.660255	4.10	.949040	1.08	.711215	5.1	
14	.660501	4.08	.948975	1.08	.711525	5.1	
15	9.660746	4.08	9.948910	1.08	9.711836	5.1	
16	.660991	4.08	.948845	1.08	.712146	5.1	
17	.661236	4.08	.948780	1.08	.712456	5.1	
18	.661481	4.08	.948715	1.08	.712766	5.1	
19	.661726	4.07	.948650	1.10	.713076	5.1	
20	9.661970	4.07	9.948584	1.08	9.713386	5.1	
21	.662214	4.08	.948519	1.08	.713696	5.1	
22	.662459	4.07	.948454	1.10	.714005	5.1	
23	.662703	4.05	.948388	1.08	.714314	5.1	
24	.662946	4.07	.948323	1.10	.714624	5.1	
25	9.663190	4.05	9.948257	1.08	9.714933	5.1	
26	.663433	4.07	.948192	1.10	.715242	5.1	
27	.663677	4.05	.948126	1.10	.715551	5.1	
28	.663920	4.05	.948060	1.08	.715860	5.1	
29	.664163	4.05	.947995	1.10	.716168	5.1	
30	9.664406	4.03	9.947929	1.10	9.716477	5.1	0.
31	.664648	4.05	.947863	1.10	.716785	5.1	.
32	.664891	4.03	.947797	1.10	.717093	5.1	.
33	.665133	4.03	.947731	1.10	.717401	5.1	.
34	.665375	4.03	.947665	1.08	.717709	5.1	.
35	9.665617	4.03	9.947600	1.12	9.718017	5.1	0.
36	.665859	4.02	.947533	1.10	.718325	5.1	.
37	.666100	4.03	.947467	1.10	.718633	5.1	.
38	.666342	4.02	.947401	1.10	.718940	5.1	.
39	.666583	4.02	.947335	1.10	.719248	5.1	.
40	9.666824	4.02	9.947269	1.10	9.719555	5.1	0.
41	.667065	4.00	.947203	1.12	.719862	5.1	.
42	.667305	4.02	.947136	1.10	.720169	5.1	.
43	.667546	4.00	.947070	1.10	.720476	5.1	.
44	.667786	4.02	.947004	1.12	.720783	5.1	.
45	9.668027	4.00	9.946937	1.10	9.721089	5.1	0.
46	.668267	3.98	.946871	1.12	.721396	5.1	.
47	.668506	4.00	.946804	1.10	.721702	5.1	.
48	.668746	4.00	.946738	1.12	.722009	5.1	.
49	.668986	3.98	.946671	1.12	.722315	5.1	.
50	9.669225	3.98	9.946604	1.10	9.722621	5.1	0.
51	.669464	3.98	.946538	1.12	.722927	5.0	.
52	.669703	3.98	.946471	1.12	.723232	5.1	.
53	.669942	3.98	.946404	1.12	.723538	5.1	.
54	.670181	3.97	.946337	1.12	.723844	5.0	.
55	9.670419	3.98	9.946270	1.12	9.724149	5.0	0.
56	.670658	3.97	.946203	1.12	.724454	5.1	.
57	.670896	3.97	.946136	1.12	.724760	5.0	.
58	.671134	3.97	.946069	1.12	.725065	5.0	.
59	.671372	3.97	.946002	1.12	.725370	5.0	.
60	9.671609	3.95	9.945935	1.12	9.725674	5.0	0.
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	T

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.671609		9.945935		9.725674		0.274326	60
.671847	3.97	.945868	1.12	.725979	5.08	.274021	59
.672084	3.95	.945800	1.13	.726284	5.08	.273716	58
.672321	3.95	.945733	1.12	.726588	5.07	.273412	57
.672558	3.95	.945666	1.12	.726892	5.07	.273108	56
9.672795	3.95	9.945598	1.13	9.727197	5.08	0.272803	55
.673032	3.93	.945531	1.12	.727501	5.07	.272499	54
.673268	3.93	.945464	1.12	.727805	5.07	.272195	53
.673505	3.95	.945396	1.13	.728109	5.07	.271891	52
.673741	3.93	.945328	1.13	.728412	5.05	.271588	51
	3.93		1.12		5.07		
9.673977		9.945261		9.728716		0.271284	50
.674213	3.93	.945193	1.13	.729020	5.07	.270980	49
.674448	3.92	.945125	1.13	.729323	5.05	.270677	48
.674684	3.93	.945058	1.12	.729626	5.05	.270374	47
.674919	3.92	.944990	1.13	.729929	5.05	.270071	46
9.675155	3.93	9.944922	1.13	9.730233	5.07	0.269767	45
.675390	3.92	.944854	1.13	.730535	5.03	.269465	44
.675624	3.90	.944786	1.13	.730838	5.05	.269162	43
.675859	3.92	.944718	1.13	.731141	5.05	.268859	42
.676094	3.92	.944650	1.13	.731444	5.05	.268556	41
	3.90		1.13		5.03		
9.676328		9.944582		9.731746		0.268254	40
.676562	3.90	.944514	1.13	.732048	5.03	.267952	39
.676796	3.90	.944446	1.13	.732351	5.05	.267649	38
.677030	3.90	.944377	1.15	.732653	5.03	.267347	37
.677264	3.90	.944309	1.13	.732955	5.03	.267045	36
9.677498	3.88	9.944241	1.13	9.733257	5.03	0.266743	35
.677731	3.88	.944172	1.15	.733558	5.02	.266442	34
.677964	3.88	.944104	1.13	.733860	5.03	.266140	33
.678197	3.88	.944036	1.13	.734162	5.03	.265838	32
.678430	3.88	.943967	1.15	.734463	5.02	.265537	31
			1.13		5.02		
9.678663		9.943899		9.734764		0.265236	30
.678895	3.87	.943830	1.15	.735066	5.03	.264934	29
.679128	3.88	.943761	1.15	.735367	5.02	.264633	28
.679360	3.87	.943693	1.13	.735668	5.02	.264332	27
.679592	3.87	.943624	1.15	.735969	5.02	.264031	26
9.679824	3.87	9.943555	1.15	9.736269	5.00	0.263731	25
.680056	3.87	.943486	1.15	.736570	5.02	.263430	24
.680288	3.87	.943417	1.15	.736870	5.00	.263130	23
.680519	3.85	.943348	1.15	.737171	5.02	.262829	22
.680750	3.85	.943279	1.15	.737471	5.00	.262529	21
	3.87		1.15		5.00		
9.680982		9.943210		9.737771		0.262229	20
.681213	3.85	.943141	1.15	.738071	5.00	.261929	19
.681443	3.83	.943072	1.15	.738371	5.00	.261629	18
.681674	3.85	.943003	1.15	.738671	5.00	.261329	17
.681905	3.85	.942934	1.17	.738971	5.00	.261029	16
.682135	3.83	9.942864	1.15	9.739271	5.00	0.260729	15
.682365	3.83	.942795	1.15	.739570	4.98	.260430	14
.682595	3.83	.942726	1.17	.739870	5.00	.260130	13
.682825	3.83	.942656	1.15	.740169	4.98	.259831	12
.683055	3.83	.942587	1.17	.740468	4.98	.259532	11
	3.82		1.17		4.98		
.683284		9.942517		9.740767		0.259233	10
.683514	3.83	.942448	1.15	.741066	4.98	.258934	9
.683743	3.82	.942378	1.17	.741365	4.98	.258635	8
.683972	3.82	.942308	1.17	.741664	4.98	.258336	7
.684201	3.82	.942239	1.15	.741962	4.97	.258038	6
.684430	3.82	9.942169	1.17	9.742261	4.98	0.257739	5
.684658	3.80	.942099	1.17	.742559	4.97	.257441	4
.684887	3.82	.942029	1.17	.742858	4.98	.257142	3
.685115	3.80	.941959	1.17	.743156	4.97	.256844	2
.685343	3.80	.941889	1.17	.743454	4.97	.256546	1
.685571	3.80	9.941819	1.17	9.743752	4.97	0.256248	0
.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

61°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.685571	3.80	9.941819	1.17	9.743752	4.97	
1	.685799	3.80	.941749	1.17	.744050	4.97	
2	.686027	3.78	.941679	1.17	.744348	4.95	
3	.686254	3.80	.941609	1.17	.744645	4.97	
4	.686482	3.78	.941539	1.17	.744943	4.95	
5	9.686709	3.78	9.941469	1.18	9.745240	4.97	
6	.686936	3.78	.941398	1.17	.745538	4.95	
7	.687163	3.77	.941328	1.17	.745835	4.95	
8	.687389	3.78	.941258	1.18	.746132	4.95	
9	.687616	3.78	.941187	1.17	.746429	4.95	
10	9.687843	3.77	9.941117	1.18	9.746726	4.95	
11	.688069	3.77	.941046	1.18	.747023	4.93	
12	.688295	3.77	.940975	1.17	.747319	4.95	
13	.688521	3.77	.940905	1.18	.747616	4.95	
14	.688747	3.75	.940834	1.18	.747913	4.93	
15	9.688972	3.77	9.940763	1.17	9.748209	4.93	0
16	.689198	3.75	.940693	1.18	.748505	4.93	.
17	.689423	3.75	.940622	1.18	.748801	4.93	.
18	.689648	3.75	.940551	1.18	.749097	4.93	.
19	.689873	3.75	.940480	1.18	.749393	4.93	.
20	9.690098	3.75	9.940409	1.18	9.749689	4.93	0.
21	.690323	3.75	.940338	1.18	.749985	4.93	.
22	.690548	3.73	.940267	1.18	.750281	4.92	.
23	.690772	3.73	.940196	1.18	.750576	4.93	.
24	.690996	3.73	.940125	1.18	.750872	4.92	.
25	9.691220	3.73	9.940054	1.20	9.751167	4.92	0.
26	.691444	3.73	.939982	1.18	.751462	4.92	.
27	.691668	3.73	.939911	1.18	.751757	4.92	.
28	.691892	3.72	.939840	1.20	.752052	4.92	.
29	.692115	3.73	.939768	1.18	.752347	4.92	.
30	9.692339	3.72	9.939697	1.20	9.752642	4.92	0.
31	.692562	3.72	.939625	1.18	.752937	4.90	.
32	.692785	3.72	.939554	1.20	.753231	4.92	.
33	.693008	3.72	.939482	1.20	.753526	4.90	.
34	.693231	3.70	.939410	1.18	.753820	4.92	.
35	9.693453	3.72	9.939339	1.20	9.754115	4.90	0.
36	.693676	3.70	.939267	1.20	.754409	4.90	.
37	.693898	3.70	.939195	1.20	.754703	4.90	.
38	.694120	3.70	.939123	1.18	.754997	4.90	.
39	.694342	3.70	.939052	1.20	.755291	4.90	.
40	9.694564	3.70	9.938980	1.20	9.755585	4.88	0.
41	.694786	3.68	.938908	1.20	.755878	4.90	.
42	.695007	3.70	.938836	1.22	.756172	4.88	.
43	.695229	3.68	.938763	1.20	.756465	4.90	.
44	.695450	3.68	.938691	1.20	.756759	4.88	.
45	9.695671	3.68	9.938619	1.20	9.757052	4.88	0.
46	.695892	3.68	.938547	1.20	.757345	4.88	.
47	.696113	3.68	.938475	1.22	.757638	4.88	.
48	.696334	3.67	.938402	1.20	.757931	4.88	.
49	.696554	3.68	.938330	1.20	.758224	4.88	.
50	9.696775	3.67	9.938258	1.22	9.758517	4.88	0.
51	.696995	3.67	.938185	1.20	.758810	4.87	.
52	.697215	3.67	.938113	1.22	.759102	4.88	.
53	.697435	3.65	.938040	1.22	.759395	4.87	.
54	.697654	3.67	.937967	1.20	.759687	4.87	.
55	9.697874	3.67	9.937895	1.22	9.759979	4.88	0.
56	.698094	3.65	.937822	1.22	.760272	4.87	.
57	.698313	3.65	.937749	1.22	.760564	4.87	.
58	.698532	3.65	.937676	1.20	.760856	4.87	.
59	.698751	3.65	.937604	1.22	.761148	4.85	.
60	9.698970		9.937531		9.761439		0.
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan

	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
	9.698970	3.65	9.937531	1.22	9.761439	4.87	0.238561	60
	.699189	3.63	.937458	1.22	.761731	4.87	.238269	59
	.699407	3.65	.937385	1.22	.762023	4.85	.237977	58
	.699626	3.63	.937312	1.23	.762314	4.87	.237686	57
	.699844	3.63	.937238	1.22	.762606	4.85	.237394	56
	9.700062	3.63	9.937165	1.22	9.762897	4.85	0.237103	55
	.700280	3.63	.937092	1.22	.763188	4.85	.236812	54
	.700498	3.63	.937019	1.22	.763479	4.85	.236521	53
	.700716	3.62	.936946	1.23	.763770	4.85	.236230	52
	.700933	3.63	.936872	1.22	.764061	4.85	.235939	51
0	9.701151	3.62	9.936799	1.23	9.764352	4.85	0.235648	50
1	.701368	3.62	.936725	1.22	.764643	4.83	.235357	49
2	.701585	3.62	.936652	1.23	.764933	4.85	.235067	48
3	.701802	3.62	.936578	1.22	.765224	4.83	.234776	47
4	.702019	3.62	.936505	1.23	.765514	4.85	.234486	46
5	9.702236	3.60	9.936431	1.23	9.765805	4.83	0.234195	45
6	.702452	3.62	.936357	1.22	.766095	4.83	.233905	44
7	.702669	3.60	.936284	1.23	.766385	4.83	.233615	43
8	.702885	3.60	.936210	1.23	.766675	4.83	.233325	42
9	.703101	3.60	.936136	1.23	.766965	4.83	.233035	41
10	9.703317	3.60	9.936062	1.23	9.767255	4.83	0.232745	40
11	.703533	3.60	.935988	1.23	.767545	4.82	.232455	39
12	.703749	3.58	.935914	1.23	.767834	4.83	.232166	38
13	.703964	3.58	.935840	1.23	.768124	4.83	.231876	37
14	.704179	3.60	.935766	1.23	.768414	4.82	.231586	36
15	9.704395	3.58	9.935692	1.23	9.768703	4.82	0.231297	35
16	.704610	3.58	.935618	1.25	.768992	4.82	.231008	34
17	.704825	3.58	.935543	1.23	.769281	4.83	.230719	33
18	.705040	3.57	.935469	1.23	.769571	4.82	.230429	32
19	.705254	3.58	.935395	1.25	.769860	4.80	.230140	31
20	9.705469	3.57	9.935320	1.23	9.770148	4.82	0.229852	30
21	.705683	3.58	.935246	1.25	.770437	4.82	.229563	29
22	.705898	3.57	.935171	1.23	.770726	4.82	.229274	28
23	.706112	3.57	.935097	1.25	.771015	4.80	.228985	27
24	.706326	3.55	.935022	1.23	.771303	4.82	.228697	26
25	9.706539	3.57	9.934948	1.25	9.771592	4.80	0.228408	25
26	.706753	3.57	.934873	1.25	.771880	4.80	.228120	24
27	.706967	3.55	.934798	1.25	.772168	4.82	.227832	23
28	.707180	3.55	.934723	1.23	.772457	4.80	.227543	22
29	.707393	3.55	.934649	1.25	.772745	4.80	.227255	21
30	9.707606	3.55	9.934574	1.25	9.773033	4.80	0.226967	20
31	.707819	3.55	.934499	1.25	.773321	4.78	.226679	19
32	.708032	3.55	.934424	1.25	.773608	4.80	.226392	18
33	.708245	3.55	.934349	1.25	.773896	4.80	.226104	17
34	.708458	3.53	.934274	1.25	.774184	4.78	.225816	16
35	9.708670	3.53	9.934199	1.27	9.774471	4.80	0.225529	15
36	.708882	3.53	.934123	1.25	.774759	4.78	.225241	14
37	.709094	3.53	.934048	1.25	.775046	4.78	.224954	13
38	.709306	3.53	.933973	1.25	.775333	4.80	.224667	12
39	.709518	3.53	.933898	1.27	.775621	4.78	.224379	11
40	9.709730	3.52	9.933822	1.25	9.775908	4.78	0.224092	10
41	.709941	3.53	.933747	1.27	.776195	4.78	.223805	9
42	.710153	3.52	.933671	1.25	.776482	4.77	.223518	8
43	.710364	3.52	.933596	1.27	.776768	4.78	.223232	7
44	.710575	3.52	.933520	1.25	.777055	4.78	.222945	6
45	9.710786	3.52	9.933445	1.27	9.777342	4.77	0.222658	5
46	.710997	3.52	.933369	1.27	.777628	4.78	.222372	4
47	.711208	3.52	.933293	1.27	.777915	4.77	.222085	3
48	.711419	3.52	.933217	1.27	.778201	4.77	.221799	2
49	.711629	3.50	.933141	1.27	.778488	4.78	.221512	1
50	9.711839	3.50	9.933066	1.25	9.778774	4.77	0.221226	0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	C
0	9.685571	3.80	9.941819	1.17	9.743752	4.97	0.
1	.685799	3.80	.941749	1.17	.744050	4.97	.
2	.686027	3.78	.941679	1.17	.744348	4.95	.
3	.686254	3.80	.941609	1.17	.744645	4.97	.
4	.686482	3.78	.941539	1.17	.744943	4.95	.
5	9.686709	3.78	9.941469	1.18	9.745240	4.97	0.
6	.686936	3.78	.941398	1.17	.745538	4.95	.
7	.687163	3.77	.941328	1.17	.745835	4.95	.
8	.687389	3.78	.941258	1.18	.746132	4.95	.
9	.687616	3.78	.941187	1.17	.746429	4.95	.
10	9.687843	3.77	9.941117	1.18	9.746726	4.95	0.
11	.688069	3.77	.941046	1.18	.747023	4.93	.
12	.688295	3.77	.940975	1.17	.747319	4.95	.
13	.688521	3.77	.940905	1.18	.747616	4.95	.
14	.688747	3.75	.940834	1.18	.747913	4.93	.
15	9.688972	3.77	9.940763	1.17	9.748209	4.93	0.
16	.689198	3.75	.940693	1.18	.748505	4.93	.
17	.689423	3.75	.940622	1.18	.748801	4.93	.
18	.689648	3.75	.940551	1.18	.749097	4.93	.
19	.689873	3.75	.940480	1.18	.749393	4.93	.
20	9.690098	3.75	9.940409	1.18	9.749689	4.93	0.
21	.690323	3.75	.940338	1.18	.749985	4.93	.
22	.690548	3.73	.940267	1.18	.750281	4.92	.
23	.690772	3.73	.940196	1.18	.750576	4.93	.
24	.690996	3.73	.940125	1.18	.750872	4.92	.
25	9.691220	3.73	9.940054	1.20	9.751167	4.92	0.
26	.691444	3.73	.939982	1.18	.751462	4.92	.
27	.691668	3.73	.939911	1.18	.751757	4.92	.
28	.691892	3.72	.939840	1.20	.752052	4.92	.
29	.692115	3.73	.939768	1.18	.752347	4.92	.
30	9.692339	3.72	9.939697	1.20	9.752642	4.92	0.
31	.692562	3.72	.939625	1.18	.752937	4.90	.
32	.692785	3.72	.939554	1.20	.753231	4.92	.
33	.693008	3.72	.939482	1.20	.753526	4.90	.
34	.693231	3.70	.939410	1.18	.753820	4.92	.
35	9.693453	3.72	9.939339	1.20	9.754115	4.90	0.
36	.693676	3.70	.939267	1.20	.754409	4.90	.
37	.693898	3.70	.939195	1.20	.754703	4.90	.
38	.694120	3.70	.939123	1.18	.754997	4.90	.
39	.694342	3.70	.939052	1.20	.755291	4.90	.
40	9 694564	3.70	9.938980	1.20	9.755585	4.88	0.
41	.694786	3.68	.938908	1.20	.755878	4.90	.
42	.695007	3.70	.938836	1.22	.756172	4.88	.
43	.695229	3.68	.938763	1.20	.756465	4.90	.
44	.695450	3.68	.938691	1.20	.756759	4.88	.
45	9.695671	3.68	9.938619	1.20	9.757052	4.88	0.
46	.695892	3.68	.938547	1.20	.757345	4.88	.
47	.696113	3.68	.938475	1.22	.757638	4.88	.
48	.696334	3.67	.938402	1.20	.757931	4.88	.
49	.696554	3.68	.938330	1.20	.758224	4.88	.
50	9.696775	3.67	9.938258	1.22	9.758517	4.88	0.
51	.696995	3.67	.938185	1.20	.758810	4.87	.
52	.697215	3.67	.938113	1.22	.759102	4.88	.
53	.697435	3.65	.938040	1.22	.759395	4.87	.
54	.697654	3.67	.937967	1.20	.759687	4.87	.
55	9.697874	3.67	9.937895	1.22	9.759979	4.88	0.
56	.698094	3.65	.937822	1.22	.760272	4.87	.
57	.698313	3.65	.937749	1.22	.760564	4.87	.
58	.698532	3.65	.937676	1.20	.760856	4.87	.
59	.698751	3.65	.937604	1.22	.761148	4.85	.
60	9.698970		9.937531		9.761439		0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	

	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
	9.724210	3.37	9.928420	1.30	9.795789	4.68	0.204211	60
	.724412	3.37	.928342	1.32	.796070	4.68	.203930	59
	.724614	3.37	.928263	1.33	.796351	4.68	.203649	58
	.724816	3.35	.928183	1.32	.796632	4.68	.203368	57
	.725017	3.37	.928104	1.32	.796913	4.68	.203087	56
	9.725219	3.35	9.928025	1.32	9.797194	4.67	0.202806	55
	.725420	3.37	.927946	1.32	.797474	4.68	.202526	54
	.725622	3.35	.927867	1.33	.797755	4.68	.202245	53
	.725823	3.35	.927787	1.32	.798036	4.67	.201964	52
	.726024	3.35	.927708	1.32	.798316	4.67	.201684	51
	9.726225	3.35	9.927629	1.33	9.798596	4.68	0.201404	50
	.726426	3.33	.927549	1.32	.798877	4.67	.201123	49
	.726626	3.35	.927470	1.33	.799157	4.67	.200843	48
	.726827	3.33	.927390	1.33	.799437	4.67	.200563	47
	.727027	3.35	.927310	1.32	.799717	4.67	.200283	46
	9.727228	3.33	9.927231	1.33	9.799997	4.67	0.200003	45
	.727428	3.33	.927151	1.33	.800277	4.67	.199723	44
	.727628	3.33	.927071	1.33	.800557	4.65	.199443	43
	.727828	3.32	.926991	1.33	.800836	4.67	.199164	42
	.728027	3.33	.926911	1.33	.801116	4.67	.198884	41
	9.728227	3.33	9.926831	1.33	9.801396	4.65	0.198604	40
	.728427	3.32	.926751	1.33	.801675	4.67	.198325	39
	.728626	3.32	.926671	1.33	.801955	4.65	.198045	38
	.728825	3.32	.926591	1.33	.802234	4.65	.197766	37
	.729024	3.32	.926511	1.33	.802513	4.65	.197487	36
	9.729223	3.32	9.926431	1.33	9.802792	4.67	0.197208	35
	.729422	3.32	.926351	1.35	.803072	4.65	.196928	34
	.729621	3.32	.926270	1.33	.803351	4.65	.196649	33
	.729820	3.30	.926190	1.33	.803630	4.65	.196370	32
	.730018	3.32	.926110	1.35	.803909	4.63	.196091	31
	9.730217	3.30	9.926029	1.33	9.804187	4.65	0.195813	30
	.730415	3.30	.925949	1.35	.804466	4.65	.195534	29
	.730613	3.30	.925868	1.33	.804745	4.63	.195255	28
	.730811	3.30	.925788	1.35	.805023	4.65	.194977	27
	.731009	3.28	.925707	1.35	.805302	4.63	.194698	26
	9.731206	3.30	9.925626	1.35	9.805580	4.65	0.194420	25
	.731404	3.30	.925545	1.33	.805859	4.63	.194141	24
	.731602	3.28	.925465	1.35	.806137	4.63	.193863	23
	.731799	3.28	.925384	1.35	.806415	4.63	.193585	22
	.731996	3.28	.925303	1.35	.806693	4.63	.193307	21
	9.732193	3.28	9.925222	1.35	9.806971	4.63	0.193029	20
	.732390	3.28	.925141	1.35	.807249	4.63	.192751	19
	.732587	3.28	.925060	1.35	.807527	4.63	.192473	18
	.732784	3.27	.924979	1.37	.807805	4.63	.192195	17
	.732980	3.28	.924897	1.35	.808083	4.63	.191917	16
	9.733177	3.27	9.924816	1.35	9.808361	4.62	0.191639	15
	.733373	3.27	.924735	1.35	.808638	4.63	.191362	14
	.733569	3.27	.924654	1.37	.808916	4.62	.191084	13
	.733765	3.27	.924572	1.35	.809193	4.63	.190807	12
	.733961	3.27	.924491	1.37	.809471	4.62	.190529	11
	9.734157	3.27	9.924409	1.35	9.809748	4.62	0.190252	10
	.734353	3.27	.924328	1.37	.810025	4.62	.189975	9
	.734549	3.25	.924246	1.37	.810302	4.63	.189698	8
	.734744	3.25	.924164	1.35	.810580	4.62	.189420	7
	.734939	3.27	.924083	1.37	.810857	4.62	.189143	6
	.735135	3.25	9.924001	1.37	9.811134	4.60	0.188866	5
	.735330	3.25	.923919	1.37	.811410	4.62	.188590	4
	.735525	3.23	.923837	1.37	.811687	4.62	.188313	3
	.735719	3.25	.923755	1.37	.811964	4.62	.188036	2
	.735914	3.25	.923673	1.37	.812241	4.60	.187759	1
	.736109		9.923591		9.812517		0.187483	0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

57°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.
0	9. 736109	3. 23	9. 923591	1. 37	9. 812517	4. 62	0. 1874
1	.736303	3. 25	.923509	1. 37	.812794	4. 60	.1872
2	.736498	3. 23	.923427	1. 37	.813070	4. 62	.1869
3	.736692	3. 23	.923345	1. 37	.813347	4. 60	.1866
4	.736886	3. 23	.923263	1. 37	.813623	4. 60	.1863
5	9. 737080	3. 23	9. 923181	1. 38	9. 813899	4. 62	0. 1861
6	.737274	3. 22	.923098	1. 37	.814176	4. 60	.1858
7	.737467	3. 23	.923016	1. 38	.814452	4. 60	.1855
8	.737661	3. 23	.922933	1. 37	.814728	4. 60	.1852
9	.737855	3. 22	.922851	1. 38	.815004	4. 60	.1849
10	9. 738048	3. 22	9. 922768	1. 37	9. 815280	4. 58	0. 1847
11	.738241	3. 22	.922686	1. 38	.815555	4. 60	.1844
12	.738434	3. 22	.922603	1. 38	.815831	4. 60	.1841
13	.738627	3. 22	.922520	1. 37	.816107	4. 58	.1838
14	.738820	3. 22	.922438	1. 38	.816382	4. 60	.1836
15	9. 739013	3. 22	9. 922355	1. 38	9. 816658	4. 58	0. 1833
16	.739206	3. 20	.922272	1. 38	.816933	4. 60	.1830
17	.739398	3. 20	.922189	1. 38	.817209	4. 58	.1827
18	.739590	3. 22	.922106	1. 38	.817484	4. 58	.1825
19	.739783	3. 20	.922023	1. 38	.817759	4. 60	.1822
20	9. 739975	3. 20	9. 921940	1. 38	9. 818035	4. 58	0. 1819
21	.740167	3. 20	.921857	1. 38	.818310	4. 58	.1816
22	.740359	3. 18	.921774	1. 38	.818585	4. 58	.1814
23	.740550	3. 20	.921691	1. 40	.818860	4. 58	.1811
24	.740742	3. 20	.921607	1. 38	.819135	4. 58	.1808
25	9. 740934	3. 18	9. 921524	1. 38	9. 819410	4. 57	0. 1805
26	.741125	3. 18	.921441	1. 40	.819684	4. 58	.1803
27	.741316	3. 20	.921357	1. 38	.819959	4. 58	.1800
28	.741508	3. 18	.921274	1. 40	.820234	4. 57	.1797
29	.741699	3. 17	.921190	1. 38	.820508	4. 58	.1794
30	9. 741889	3. 18	9. 921107	1. 40	9. 820783	4. 57	0. 1792
31	.742080	3. 18	.921023	1. 40	.821057	4. 58	.1789
32	.742271	3. 18	.920939	1. 38	.821332	4. 57	.1786
33	.742462	3. 17	.920856	1. 40	.821606	4. 57	.1783
34	.742652	3. 17	.920772	1. 40	.821880	4. 57	.1781
35	9. 742842	3. 18	9. 920688	1. 40	9. 822154	4. 58	0. 1778
36	.743033	3. 17	.920604	1. 40	.822429	4. 57	.1775
37	.743223	3. 17	.920520	1. 40	.822703	4. 57	.1772
38	.743413	3. 15	.920436	1. 40	.822977	4. 57	.1770
39	.743602	3. 17	.920352	1. 40	.823251	4. 55	.1767
40	9. 743792	3. 17	9. 920268	1. 40	9. 823524	4. 57	0. 1764
41	.743982	3. 15	.920184	1. 42	.823798	4. 57	.1762
42	.744171	3. 17	.920099	1. 40	.824072	4. 55	.1759
43	.744361	3. 15	.920015	1. 40	.824345	4. 57	.1756
44	.744550	3. 15	.919931	1. 42	.824619	4. 57	.1753
45	9. 744739	3. 15	9. 919846	1. 40	9. 824893	4. 57	0. 1751
46	.744928	3. 15	.919762	1. 42	.825166	4. 55	.1748
47	.745117	3. 15	.919677	1. 40	.825439	4. 55	.1745
48	.745306	3. 13	.919593	1. 42	.825713	4. 57	.1742
49	.745494	3. 15	.919508	1. 40	.825986	4. 55	.1740
50	9. 745683	3. 13	9. 919424	1. 42	9. 826259	4. 55	0. 1737
51	.745871	3. 15	.919339	1. 42	.826532	4. 55	.1734
52	.746060	3. 13	.919254	1. 42	.826805	4. 55	.1731
53	.746248	3. 13	.919169	1. 40	.827078	4. 55	.1728
54	.746436	3. 13	.919085	1. 42	.827351	4. 55	.1726
55	9. 746624	3. 13	9. 919000	1. 42	9. 827624	4. 55	0. 1723
56	.746812	3. 12	.918915	1. 42	.827897	4. 55	.1720
57	.746999	3. 13	.918830	1. 42	.828170	4. 55	.1717
58	.747187	3. 12	.918745	1. 43	.828442	4. 53	.1715
59	.747374	3. 13	.918659	1. 42	.828715	4. 55	.1712
60	9. 747562		9. 918574		9. 828987	4. 53	0. 1709
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan

in.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
7562		9.918574	1.42	9.828987	4.55	0.171013	60
7749	3.12	.918489	1.42	.829260	4.53	.170740	59
7936	3.12	.918404	1.43	.829532	4.55	.170468	58
8123	3.12	.918318	1.42	.829805	4.53	.170195	57
8310	3.12	.918233	1.43	.830077	4.53	0.169923	56
8497	3.12	9.918147	1.42	9.830349	4.53	.169651	55
8683	3.10	.918062	1.43	.830621	4.53	.169379	54
8870	3.12	.917976	1.42	.830893	4.53	.169107	53
9056	3.10	.917891	1.43	.831165	4.53	.168835	52
9243	3.12	.917805	1.43	.831437	4.53	.168563	51
9429	3.10	9.917719	1.42	9.831709	4.53	0.168291	50
9615	3.10	.917634	1.43	.831981	4.53	.168019	49
9801	3.10	.917548	1.43	.832253	4.53	.167747	48
9987	3.10	.917462	1.43	.832525	4.52	.167475	47
0172	3.08	.917376	1.43	.832796	4.53	.167204	46
0358	3.10	9.917290	1.43	9.833068	4.52	0.166932	45
0543	3.08	.917204	1.43	.833339	4.53	.166661	44
0729	3.10	.917118	1.43	.833611	4.53	.166389	43
0914	3.08	.917032	1.43	.833882	4.52	.166118	42
1099	3.08	.916946	1.45	.834154	4.53	.165846	41
1284	3.08	9.916859	1.43	9.834425	4.52	0.165575	40
1469	3.08	.916773	1.43	.834696	4.52	.165304	39
1654	3.08	.916687	1.43	.834967	4.52	.165033	38
1839	3.08	.916600	1.45	.835238	4.52	.164762	37
2023	3.07	.916514	1.43	.835509	4.52	.164491	36
2208	3.08	9.916427	1.45	9.835780	4.52	0.164220	35
2392	3.07	.916341	1.43	.836051	4.52	.163949	34
2576	3.07	.916254	1.45	.836322	4.52	.163678	33
2760	3.07	.916167	1.45	.836593	4.52	.163407	32
2944	3.07	.916081	1.43	.836864	4.52	.163136	31
3128	3.07	9.915994	1.45	9.837134	4.50	0.162866	30
312	3.05	.915907	1.45	.837405	4.52	.162595	29
495	3.07	.915820	1.45	.837675	4.50	.162325	28
679	3.05	.915733	1.45	.837946	4.52	.162054	27
862	3.07	.915646	1.45	.838216	4.50	.161784	26
046	3.05	9.915559	1.45	9.838487	4.52	0.161513	25
229	3.05	.915472	1.45	.838757	4.50	.161243	24
412	3.05	.915385	1.47	.839027	4.50	.160973	23
595	3.05	.915297	1.45	.839297	4.50	.160703	22
778	3.05	.915210	1.45	.839568	4.52	.160432	21
960	3.05	9.915123	1.47	9.839838	4.50	0.160162	20
143	3.05	.915035	1.45	.840108	4.50	.159892	19
326	3.03	.914948	1.47	.840378	4.50	.159622	18
508	3.03	.914860	1.45	.840648	4.48	.159352	17
690	3.03	.914773	1.47	.840917	4.50	.159083	16
872	3.03	9.914685	1.45	9.841187	4.50	0.158813	15
054	3.03	.914598	1.47	.841457	4.50	.158543	14
236	3.03	.914510	1.47	.841727	4.48	.158273	13
418	3.03	.914422	1.47	.841996	4.50	.158004	12
600	3.03	.914334	1.47	.842266	4.48	.157734	11
782	3.02	9.914246	1.47	9.842535	4.50	0.157465	10
963	3.02	.914158	1.47	.842805	4.48	.157195	9
145	3.03	.914070	1.47	.843074	4.48	.156926	8
326	3.02	.913982	1.47	.843343	4.48	.156657	7
508	3.02	.913894	1.47	.843612	4.50	.156388	6
689	3.02	9.913806	1.47	9.843882	4.48	0.156118	5
870	3.02	.913718	1.47	.844151	4.48	.155849	4
052	3.02	.913630	1.48	.844420	4.48	.155580	3
233	3.00	.913541	1.47	.844689	4.48	.155311	2
414	3.02	.913453	1.47	.844958	4.48	.155042	1
595	3.00	9.913365		9.845227		0.154773	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

55°

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	C
0	9.758591		9.913365		9.845227		0.
1	.758772	3.02	.913276	1.48	.845496	4.48	.
2	.758952	3.00	.913187	1.48	.845764	4.47	.
3	.759132	3.00	.913099	1.47	.846033	4.48	.
4	.759312	3.00	.913010	1.48	.846302	4.48	.
5	9.759492	3.00	9.912922	1.47	9.846570	4.47	0.
6	.759672	3.00	.912833	1.48	.846839	4.48	.
7	.759852	3.00	.912744	1.48	.847108	4.48	.
8	.760031	2.98	.912655	1.48	.847376	4.47	.
9	.760211	3.00	.912566	1.48	.847644	4.47	.
10	9.760390	2.98	9.912477	1.48	9.847913	4.48	0.
11	.760569	2.98	.912388	1.48	.848181	4.47	.
12	.760748	2.98	.912299	1.48	.848449	4.47	.
13	.760927	2.98	.912210	1.48	.848717	4.47	.
14	.761106	2.98	.912121	1.48	.848986	4.48	.
15	9.761285	2.98	9.912031	1.50	9.849254	4.47	0.
16	.761464	2.97	.911942	1.48	.849522	4.47	.
17	.761642	2.98	.911853	1.48	.849790	4.47	.
18	.761821	2.97	.911763	1.50	.850057	4.45	.
19	.761999	2.97	.911674	1.48	.850325	4.47	.
20	9.762177	2.98	9.911584	1.50	9.850593	4.47	0.
21	.762356	2.97	.911495	1.48	.850861	4.47	.
22	.762534	2.97	.911405	1.50	.851129	4.45	.
23	.762712	2.95	.911315	1.50	.851396	4.47	.
24	.762889	2.97	.911226	1.48	.851664	4.45	.
25	9.763067	2.97	9.911136	1.50	9.851931	4.47	0.
26	.763245	2.95	.911046	1.50	.852199	4.45	.
27	.763422	2.97	.910956	1.50	.852466	4.45	.
28	.763600	2.95	.910866	1.50	.852733	4.47	.
29	.763777	2.95	.910776	1.50	.853001	4.45	.
30	9.763954	2.95	9.910686	1.50	9.853268	4.45	0.
31	.764131	2.95	.910596	1.50	.853535	4.45	.
32	.764308	2.95	.910506	1.52	.853802	4.45	.
33	.764485	2.95	.910415	1.50	.854069	4.45	.
34	.764662	2.93	.910325	1.50	.854336	4.45	.
35	9.764838	2.95	9.910235	1.52	9.854603	4.45	0.
36	.765015	2.93	.910144	1.50	.854870	4.45	.
37	.765191	2.93	.910054	1.52	.855137	4.45	.
38	.765367	2.95	.909963	1.50	.855404	4.45	.
39	.765544	2.93	.909873	1.52	.855671	4.45	.
40	9.765720	2.93	9.909782	1.52	9.855938	4.43	0.
41	.765896	2.93	.909691	1.50	.856204	4.45	.
42	.766072	2.92	.909601	1.52	.856471	4.43	.
43	.766247	2.93	.909510	1.52	.856737	4.45	.
44	.766423	2.92	.909419	1.52	.857004	4.43	.
45	9.766598	2.93	9.909328	1.52	9.857270	4.45	0.
46	.766774	2.92	.909237	1.52	.857537	4.43	.
47	.766949	2.92	.909146	1.52	.857803	4.43	.
48	.767124	2.93	.909055	1.52	.858069	4.45	.
49	.767300	2.92	.908964	1.52	.858336	4.43	.
50	9.767475	2.90	9.908873	1.53	9.858602	4.43	0.
51	.767649	2.92	.908781	1.52	.858868	4.43	.
52	.767824	2.92	.908690	1.52	.859134	4.43	.
53	.767999	2.90	.908599	1.53	.859400	4.43	.
54	.768173	2.92	.908507	1.52	.859666	4.43	.
55	9.768348	2.90	9.908416	1.53	9.859932	4.43	0.
56	.768522	2.92	.908324	1.52	.860198	4.43	.
57	.768697	2.90	.908233	1.53	.860464	4.43	.
58	.768871	2.90	.908141	1.53	.860730	4.42	.
59	.769045	2.90	.908049	1.53	.860995	4.43	.
60	9.769219		9.907958	1.52	9.861261		
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	

D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
	9.907958		9.861261		0.138739	60
2.90	.907866	1.53	.861527	4.43	.138473	59
2.88	.907774	1.53	.861792	4.42	.138208	58
2.90	.907682	1.53	.862058	4.43	.137942	57
2.88	.907590	1.53	.862323	4.42	.137677	56
2.90	9.907498	1.53	9.862589	4.43	0.137411	55
2.88	.907406	1.53	.862854	4.42	.137146	54
2.88	.907314	1.53	.863119	4.42	.136881	53
2.88	.907222	1.53	.863385	4.43	.136615	52
2.88	.907129	1.55	.863650	4.42	.136350	51
		1.53		4.42		
	9.907037		9.863915		0.136085	50
2.88	.906945	1.53	.864180	4.42	.135820	49
2.88	.906852	1.55	.864445	4.42	.135555	48
2.87	.906760	1.53	.864710	4.42	.135290	47
2.88	.906667	1.55	.864975	4.42	.135025	46
2.87	9.906575	1.53	9.865240	4.42	0.134760	45
2.87	.906482	1.55	.865505	4.42	.134495	44
2.87	.906389	1.55	.865770	4.42	.134230	43
2.87	.906296	1.55	.866035	4.42	.133965	42
2.87	.906204	1.53	.866300	4.42	.133700	41
		1.55		4.40		
	9.906111		9.866564		0.133436	40
2.87	.906018	1.55	.866829	4.42	.133171	39
2.85	.905925	1.55	.867094	4.42	.132906	38
2.87	.905832	1.55	.867358	4.40	.132642	37
2.85	.905739	1.55	.867623	4.42	.132377	36
2.87	9.905645	1.57	9.867887	4.40	0.132113	35
2.85	.905552	1.55	.868152	4.42	.131848	34
2.85	.905459	1.55	.868416	4.40	.131584	33
2.85	.905366	1.55	.868680	4.40	.131320	32
2.85	.905272	1.57	.868945	4.42	.131055	31
		1.55		4.40		
	9.905179		9.869209		0.130791	30
2.83	.905085	1.57	.869473	4.40	.130527	29
2.85	.904992	1.55	.869737	4.40	.130263	28
2.83	.904898	1.57	.870001	4.40	.129999	27
2.85	.904804	1.57	.870265	4.40	.129735	26
2.83	9.904711	1.55	9.870529	4.40	0.129471	25
2.83	.904617	1.57	.870793	4.40	.129207	24
2.83	.904523	1.57	.871057	4.40	.128943	23
2.83	.904429	1.57	.871321	4.40	.128679	22
2.83	.904335	1.57	.871585	4.40	.128415	21
		1.57		4.40		
	9.904241		9.871849		0.128151	20
2.82	.904147	1.57	.872112	4.38	.127888	19
2.83	.904053	1.57	.872376	4.40	.127624	18
2.82	.903959	1.57	.872640	4.40	.127360	17
2.83	.903864	1.58	.872903	4.38	.127097	16
2.82	9.903770	1.57	9.873167	4.40	0.126833	15
2.82	.903676	1.57	.873430	4.38	.126570	14
2.82	.903581	1.58	.873694	4.40	.126306	13
2.82	.903487	1.57	.873957	4.38	.126043	12
2.82	.903392	1.58	.874220	4.38	.125780	11
2.80		1.57		4.40		
	9.903298		9.874484		0.125516	10
2.82	.903203	1.58	.874747	4.38	.125253	9
2.82	.903108	1.58	.875010	4.38	.124990	8
2.80	.903014	1.57	.875273	4.38	.124727	7
2.80	.902919	1.58	.875537	4.40	.124463	6
2.82	9.902824	1.58	9.875800	4.38	0.124200	5
2.80	.902729	1.58	.876063	4.38	.123937	4
2.80	.902634	1.58	.876326	4.38	.123674	3
2.80	.902539	1.58	.876589	4.38	.123411	2
2.78	.902444	1.58	.876852	4.38	.123148	1
2.80	9.902349	1.58	9.877114	4.37	0.122886	0
D. 1″.	Sin.	D. 1″.	℄		Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.779463	2.80	9.902349	1.60	9.877114	4.38	0
1	.779631	2.78	.902253	1.58	.877377	4.38	
2	.779798	2.80	.902158	1.58	.877640	4.38	
3	.779966	2.78	.902063	1.60	.877903	4.37	
4	.780133	2.78	.901967	1.58	.878165	4.38	
5	9.780300	2.78	9.901872	1.60	9.878428	4.38	0.
6	.780467	2.78	.901776	1.58	.878691	4.37	
7	.780634	2.78	.901681	1.60	.878953	4.38	.1
8	.780801	2.78	.901585	1.58	.879216	4.37	.1
9	.780968	2.77	.901490	1.60	.879478	4.38	.1
10	9.781134	2.78	9.901394	1.60	9.879741	4.37	0.1
11	.781301	2.78	.901298	1.60	.880003	4.37	.1
12	.781468	2.77	.901202	1.60	.880265	4.38	.11
13	.781634	2.77	.901106	1.60	.880528	4.37	.11
14	.781800	2.77	.901010	1.60	.880790	4.37	.11
15	9.781966	2.77	9.900914	1.60	9.881052	4.37	0.11
16	.782132	2.77	.900818	1.60	.881314	4.38	.11
17	.782298	2.77	.900722	1.60	.881577	4.37	.118
18	.782464	2.77	.900626	1.62	.881839	4.37	.118
19	.782630	2.77	.900529	1.60	.882101	4.37	.117
20	9.782796	2.75	9.900433	1.60	9.882363	4.37	0.117
21	.782961	2.77	.900337	1.62	.882625	4.37	.117
22	.783127	2.75	.900240	1.60	.882887	4.35	.1171
23	.783292	2.77	.900144	1.62	.883148	4.37	.1168
24	.783458	2.75	.900047	1.60	.883410	4.37	.1165
25	9.783623	2.75	9.899951	1.62	9.883672	4.37	0.1163
26	.783788	2.75	.899854	1.62	.883934	4.37	.1160
27	.783953	2.75	.899757	1.62	.884196	4.35	.1158
28	.784118	2.73	.899660	1.60	.884457	4.37	.1155
29	.784282	2.75	.899564	1.62	.884719	4.35	.1152
30	9.784447	2.75	9.899467	1.62	9.884980	4.37	0.1150
31	.784612	2.73	.899370	1.62	.885242	4.37	.1147
32	.784776	2.75	.899273	1.62	.885504	4.35	.1144
33	.784941	2.73	.899176	1.63	.885765	4.35	.1142
34	.785105	2.73	.899078	1.62	.886026	4.37	.1139
35	9.785269	2.73	9.898981	1.62	9.886288	4.35	0.1137
36	.785433	2.73	.898884	1.62	.886549	4.37	.1134
37	.785597	2.73	.898787	1.63	.886811	4.35	.1131
38	.785761	2.73	.898689	1.62	.887072	4.35	.1129
39	.785925	2.73	.898592	1.63	.887333	4.35	.1126
40	9.786089	2.72	9.898494	1.62	9.887594	4.35	0.1124
41	.786252	2.73	.898397	1.63	.887855	4.35	.1121
42	.786416	2.72	.898299	1.62	.888116	4.37	.1118
43	.786579	2.72	.898202	1.63	.888378	4.35	.1116
44	.786742	2.73	.898104	1.63	.888639	4.35	.1113
45	9.786906	2.72	9.898006	1.63	9.888900	4.35	0.1110
46	.787069	2.72	.897908	1.63	.889161	4.33	.1108
47	.787232	2.72	.897810	1.63	.889421	4.35	.1105
48	.787395	2.70	.897712	1.63	.889682	4.35	.1103
49	.787557	2.72	.897614	1.63	.889943	4.35	.1100
50	9.787720	2.72	9.897516	1.63	9.890204	4.35	0.1097
51	.787883	2.70	.897418	1.63	.890465	4.33	.1095
52	.788045	2.72	.897320	1.63	.890725	4.35	.1092
53	.788208	2.70	.897222	1.65	.890986	4.35	.1090
54	.788370	2.70	.897123	1.63	.891247	4.33	.1087
55	9.788532	2.70	9.897025	1.65	9.891507	4.35	0.1084
56	.788694	2.70	.896926	1.63	.891768	4.33	.1082
57	.788856	2.70	.896828	1.65	.892028	4.35	.1079
58	.789018	2.70	.896729	1.63	.892289	4.33	.1077
59	.789180	2.70	.896631	1.65	.892549	4.35	.1074
60	9.789342		9.896532		9.892810		0.1071
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.789342	2.70	9.896532	1.65	9.892810	4.33	0.107190	60
.789504	2.68	.896433	1.63	.893070	4.35	.106930	59
.789665	2.70	.896335	1.65	.893331	4.33	.106669	58
.789827	2.68	.896236	1.65	.893591	4.33	.106409	57
.789988	2.68	.896137	1.65	.893851	4.33	.106149	56
9.790149	2.68	9.896038	1.65	9.894111	4.35	0.105889	55
.790310	2.68	.895939	1.65	.894372	4.33	.105628	54
.790471	2.68	.895840	1.65	.894632	4.33	.105368	53
.790632	2.68	.895741	1.67	.894892	4.33	.105108	52
.790793	2.68	.895641	1.65	.895152	4.33	.104848	51
9.790954	2.68	9.895542	1.65	9.895412	4.33	0.104588	50
.791115	2.67	.895443	1.67	.895672	4.33	.104328	49
.791275	2.68	.895343	1.65	.895932	4.33	.104068	48
.791436	2.67	.895244	1.65	.896192	4.33	.103808	47
.791596	2.68	.895145	1.67	.896452	4.33	.103548	46
9.791757	2.67	9.895045	1.67	9.896712	4.32	0.103288	45
.791917	2.67	.894945	1.65	.896971	4.33	.103029	44
.792077	2.67	.894846	1.67	.897231	4.33	.102769	43
.792237	2.67	.894746	1.67	.897491	4.33	.102509	42
.792397	2.67	.894646	1.67	.897751	4.32	.102249	41
9.792557	2.65	9.894546	1.67	9.898010	4.33	0.101990	40
.792716	2.67	.894446	1.67	.898270	4.33	.101730	39
.792876	2.65	.894346	1.67	.898530	4.32	.101470	38
.793035	2.67	.894246	1.67	.898789	4.33	.101211	37
.793195	2.65	.894146	1.67	.899049	4.32	.100951	36
9.793354	2.67	9.894046	1.67	9.899308	4.33	0.100692	35
.793514	2.65	.893946	1.67	.899568	4.32	.100432	34
.793673	2.65	.893846	1.68	.899827	4.33	.100173	33
.793832	2.65	.893745	1.67	.900087	4.32	.099913	32
.793991	2.65	.893645	1.68	.900346	4.32	.099654	31
9.794150	2.63	9.893544	1.67	9.900605	4.32	0.099395	30
.794308	2.65	.893444	1.68	.900864	4.33	.099136	29
.794467	2.65	.893343	1.67	.901124	4.32	.098876	28
.794626	2.63	.893243	1.68	.901383	4.32	.098617	27
.794784	2.63	.893142	1.68	.901642	4.32	.098358	26
.794942	2.65	9.893041	1.68	9.901901	4.32	0.098099	25
795101	2.63	.892940	1.68	.902160	4.33	.097840	24
795259	2.63	.892839	1.67	.902420	4.32	.097580	23
795417	2.63	.892739	1.68	.902679	4.32	.097321	22
795575	2.63	.892638	1.70	.902938	4.32	.097062	21
795733	2.63	9.892536	1.68	9.903197	4.32	0.096803	20
795891	2.63	.892435	1.68	.903456	4.30	.096544	19
796049	2.62	.892334	1.68	.903714	4.32	.096286	18
796206	2.63	.892233	1.68	.903973	4.32	.096027	17
796364	2.62	.892132	1.70	.904232	4.32	.095768	16
796521	2.63	9.892030	1.68	9.904491	4.32	0.095509	15
796679	2.62	.891929	1.70	.904750	4.30	.095250	14
796836	2.62	.891827	1.68	.905008	4.32	.094992	13
796993	2.62	.891726	1.70	.905267	4.32	.094733	12
797150	2.62	.891624	1.68	.905526	4.32	.094474	11
797307	2.62	9.891523	1.70	9.905785	4.30	0.094215	10
797464	2.62	.891421	1.70	.906043	4.32	.093957	9
797621	2.60	.891319	1.70	.906302	4.30	.093698	8
797777	2.62	.891217	1.70	.906560	4.32	.093440	7
797934	2.62	.891115	1.70	.906819	4.30	.093181	6
798091	2.60	9.891013	1.70	9.907077	4.32	0.092923	5
798247	2.60	.890911	1.70	.907336	4.30	.092664	4
798403	2.62	.890809	1.70	.907594	4.32	.092406	3
798560	2.60	.890707	1.70	.907853	4.30	.092147	2
798716	2.60	.890605	1.70	.908111	4.30	.091889	1
798872	2.60	9.890503	1.70	9.908369	4.30	0.091631	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

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M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	
0	9.798872	2.60	9.890503	1.72	9.908369	4.32	
1	.799028	2.60	.890400	1.70	.908628	4.30	
2	.799184	2.58	.890298	1.72	.908886	4.30	
3	.799339	2.60	.890195	1.70	.909144	4.30	
4	.799495	2.60	.890093	1.72	.909402	4.30	
5	9.799651	2.58	9.889990	1.70	9.909660	4.30	
6	.799806	2.60	.889888	1.72	.909918	4.32	
7	.799962	2.58	.889785	1.72	.910177	4.30	
8	.800117	2.58	.889682	1.72	.910435	4.30	
9	.800272	2.58	.889579	1.70	.910693	4.30	
10	9.800427	2.58	9.889477	1.72	9.910951	4.30	0.
11	.800582	2.58	.889374	1.72	.911209	4.30	.
12	.800737	2.58	.889271	1.72	.911467	4.30	.
13	.800892	2.58	.889168	1.73	.911725	4.28	.
14	.801047	2.57	.889064	1.72	.911982	4.30	.
15	9.801201	2.58	9.888961	1.72	9.912240	4.30	0.
16	.801356	2.58	.888858	1.72	.912498	4.30	.
17	.801511	2.57	.888755	1.73	.912756	4.30	.
18	.801665	2.57	.888651	1.72	.913014	4.28	.
19	.801819	2.57	.888548	1.73	.913271	4.30	.
20	9.801973	2.58	9.888444	1.72	9.913529	4.30	0.
21	.802128	2.57	.888341	1.73	.913787	4.28	.
22	.802282	2.57	.888237	1.72	.914044	4.30	.
23	.802436	2.55	.888134	1.73	.914302	4.30	.
24	.802589	2.57	.888030	1.73	.914560	4.28	.
25	9.802743	2.57	9.887926	1.73	9.914817	4.30	0.
26	.802897	2.55	.887822	1.73	.915075	4.28	.
27	.803050	2.57	.887718	1.73	.915332	4.30	.
28	.803204	2.55	.887614	1.73	.915590	4.28	.
29	.803357	2.57	.887510	1.73	.915847	4.28	.
30	9.803511	2.55	9.887406	1.73	9.916104	4.30	0.
31	.803664	2.55	.887302	1.73	.916362	4.28	.
32	.803817	2.55	.887198	1.75	.916619	4.30	.
33	.803970	2.55	.887093	1.73	.916877	4.28	.
34	.804123	2.55	.886989	1.73	.917134	4.28	.
35	9.804276	2.53	9.886885	1.75	9.917391	4.28	0.
36	.804428	2.55	.886780	1.73	.917648	4.30	.
37	.804581	2.55	.886676	1.75	.917906	4.28	.
38	.804734	2.53	.886571	1.75	.918163	4.28	.
39	.804886	2.55	.886466	1.73	.918420	4.28	.
40	9.805039	2.53	9.886362	1.75	9.918677	4.28	0.
41	.805191	2.53	.886257	1.75	.918934	4.28	.
42	.805343	2.53	.886152	1.75	.919191	4.28	.
43	.805495	2.53	.886047	1.75	.919448	4.28	.
44	.805647	2.53	.885942	1.75	.919705	4.28	.
45	9.805799	2.53	9.885837	1.75	9.919962	4.28	0.
46	.805951	2.53	.885732	1.75	.920219	4.28	.
47	.806103	2.52	.885627	1.75	.920476	4.28	.
48	.806254	2.53	.885522	1.77	.920733	4.28	.
49	.806406	2.52	.885416	1.75	.920990	4.28	.
50	9.806557	2.53	9.885311	1.77	9.921247	4.27	0.
51	.806709	2.52	.885205	1.75	.921503	4.28	.
52	.806860	2.52	.885100	1.77	.921760	4.28	.
53	.807011	2.53	.884994	1.75	.922017	4.28	.
54	.807163	2.52	.884889	1.77	.922274	4.27	.
55	9.807314	2.52	9.884783	1.77	9.922530	4.28	0.
56	.807465	2.52	.884677	1.75	.922787	4.28	.
57	.807615	2.50	.884572	1.77	.923044	4.28	.
58	.807766	2.52	.884466	1.77	.923300	4.27	.
59	.807917	2.52	.884360	1.77	.923557	4.28	.
60	9.808067	2.50	9.884254	1.77	9.923814	4.28	0.
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

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Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.808067	2.52	9.884254	1.77	9.923814	4.27	0.076186	60
.808218	2.50	.884148	1.77	.924070	4.28	.075930	59
.808368	2.52	.884042	1.77	.924327	4.27	.075673	58
.808519	2.50	.883936	1.78	.924583	4.28	.075417	57
.808669	2.50	.883829	1.77	.924840	4.27	.075160	56
9.808819	2.50	9.883723	1.77	9.925096	4.27	0.074904	55
.808969	2.50	.883617	1.78	.925352	4.28	.074648	54
.809119	2.50	.883510	1.77	.925609	4.27	.074391	53
.809269	2.50	.883404	1.78	.925865	4.28	.074135	52
.809419	2.50	.883297	1.77	.926122	4.27	.073878	51
9.809569	2.48	9.883191	1.78	9.926378	4.27	0.073622	50
.809718	2.50	.883084	1.78	.926634	4.27	.073366	49
.809868	2.48	.882977	1.77	.926890	4.28	.073110	48
.810017	2.50	.882871	1.78	.927147	4.27	.072853	47
.810167	2.48	.882764	1.78	.927403	4.27	.072597	46
9.810316	2.48	9.882657	1.78	9.927659	4.27	0.072341	45
.810465	2.48	.882550	1.78	.927915	4.27	.072085	44
.810614	2.48	.882443	1.78	.928171	4.27	.071829	43
.810763	2.48	.882336	1.78	.928427	4.28	.071573	42
.810912	2.48	.882229	1.80	.928684	4.27	.071316	41
9.811061	2.48	9.882121	1.78	9.928940	4.27	0.071060	40
.811210	2.47	.882014	1.78	.929196	4.27	.070804	39
.811358	2.48	.881907	1.80	.929452	4.27	.070548	38
.811507	2.47	.881799	1.78	.929708	4.27	.070292	37
.811655	2.48	.881692	1.80	.929964	4.27	.070036	36
9.811804	2.47	9.881584	1.78	9.930220	4.25	0.069780	35
.811952	2.47	.881477	1.80	.930475	4.27	.069525	34
.812100	2.47	.881369	1.80	.930731	4.27	.069269	33
.812248	2.47	.881261	1.80	.930987	4.27	.069013	32
.812396	2.47	.881153	1.78	.931243	4.27	.068757	31
9.812544	2.47	9.881046	1.80	9.931499	4.27	0.068501	30
.812692	2.47	.880938	1.80	.931755	4.25	.068245	29
.812840	2.47	.880830	1.80	.932010	4.27	.067990	28
.812988	2.45	.880722	1.82	.932266	4.27	.067734	27
.813135	2.47	.880613	1.80	.932522	4.27	.067478	26
9.813283	2.45	9.880505	1.80	9.932778	4.25	0.067222	25
.813430	2.47	.880397	1.80	.933033	4.27	.066967	24
.813578	2.45	.880289	1.82	.933289	4.27	.066711	23
.813725	2.45	.880180	1.80	.933545	4.25	.066455	22
.813872	2.45	.880072	1.82	.933800	4.27	.066200	21
.814019	2.45	9.879963	1.80	9.934056	4.25	0.065944	20
814166	2.45	.879855	1.82	.934311	4.27	.065689	19
814313	2.45	.879746	1.82	.934567	4.25	.065433	18
814460	2.45	.879637	1.80	.934822	4.27	.065178	17
814607	2.43	.879529	1.82	.935078	4.25	.064922	16
814753	2.45	9.879420	1.82	9.935333	4.27	0.064667	15
814900	2.43	.879311	1.82	.935589	4.25	.064411	14
15046	2.45	.879202	1.82	.935844	4.27	.064156	13
15193	2.43	.879093	1.82	.936100	4.25	.063900	12
15339	2.43	.878984	1.82	.936355	4.27	.063645	11
15485	2.45	9.878875	1.82	9.936611	4.25	0.063389	10
15632	2.43	.878765	1.83	.936866	4.25	.063134	9
15778	2.43	.878656	1.82	.937121	4.27	.062879	8
15924	2.42	.878547	1.82	.937377	4.25	.062623	7
16069	2.43	.878438	1.83	.937632	4.25	.062368	6
16215	2.43	9.878329	1.82	9.937887	4.25	0.062113	5
16361	2.43	.878219	1.82	.938142	4.27	.061858	4
16507	2.43	.878110	1.83	.938398	4.25	.061602	3
16652	2.42	.878000	1.82	.938653	4.25	.061347	2
16798	2.43	.877891	1.82	.938908	4.25	.061092	1
16943	2.42	9.877781	1.83	9.939163	4.25	0.060837	0
	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
0	9.816943	2.42	9.877780	1.83	9.939163	4.25	0.060837	60
1	.817088	2.42	.877670	1.83	.939418	4.25	.060582	59
2	.817233	2.42	.877560	1.83	.939673	4.25	.060327	58
3	.817379	2.43	.877450	1.83	.939928	4.25	.060072	57
4	.817524	2.42	.877340	1.83	.940183	4.25	.059817	56
5	9.817668	2.40	9.877230	1.83	9.940439	4.27	0.059561	55
6	.817813	2.42	.877120	1.83	.940694	4.25	.059306	54
7	.817958	2.42	.877010	1.83	.940949	4.25	.059051	53
8	.818103	2.42	.876899	1.85	.941204	4.25	.058796	52
9	.818247	2.40	.876789	1.83	.941459	4.25	.058541	51
10	9.818392	2.42	9.876678	1.85	9.941713	4.23	0.058287	50
11	.818536	2.40	.876568	1.83	.941968	4.25	.058032	49
12	.818681	2.42	.876457	1.85	.942223	4.25	.057777	48
13	.818825	2.40	.876347	1.83	.942478	4.25	.057522	47
14	.818969	2.40	.876236	1.85	.942733	4.25	.057267	46
15	9.819113	2.40	9.876125	1.85	9.942988	4.25	0.057012	45
16	.819257	2.40	.876014	1.83	.943243	4.25	.056757	44
17	.819401	2.40	.875904	1.85	.943498	4.23	.056502	43
18	.819545	2.40	.875793	1.85	.943752	4.25	.056248	42
19	.819689	2.38	.875682	1.85	.944007	4.25	.055993	41
20	9.819832	2.40	9.875571	1.87	9.944262	4.25	0.055738	40
21	.819976	2.40	.875459	1.85	.944517	4.23	.055483	39
22	.820120	2.38	.875348	1.85	.944771	4.25	.055229	38
23	.820263	2.38	.875237	1.85	.945026	4.25	.054974	37
24	.820406	2.40	.875126	1.87	.945281	4.23	.054719	36
25	9.820550	2.38	9.875014	1.85	9.945535	4.25	0.054465	35
26	.820693	2.38	.874903	1.87	.945790	4.25	.054210	34
27	.820836	2.38	.874791	1.85	.946045	4.23	.053955	33
28	.820979	2.38	.874680	1.87	.946299	4.25	.053701	32
29	.821122	2.38	.874568	1.87	.946554	4.23	.053446	31
30	9.821265	2.37	9.874456	1.87	9.946808	4.25	0.053192	30
31	.821407	2.38	.874344	1.87	.947063	4.25	.052937	29
32	.821550	2.38	.874232	1.85	.947318	4.23	.052682	28
33	.821693	2.37	.874121	1.87	.947572	4.25	.052428	27
34	.821835	2.37	.874009	1.88	.947827	4.23	.052173	26
35	9.821977	2.38	9.873896	1.87	9.948081	4.23	0.051919	25
36	.822120	2.37	.873784	1.87	.948335	4.25	.051665	24
37	.822262	2.37	.873672	1.87	.948590	4.23	.051410	23
38	.822404	2.37	.873560	1.87	.948844	4.25	.051156	22
39	.822546	2.37	.873448	1.88	.949099	4.23	.050901	21
40	9.822688	2.37	9.873335	1.87	9.949353	4.25	0.050647	20
41	.822830	2.37	.873223	1.88	.949608	4.23	.050392	19
42	.822972	2.37	.873110	1.87	.949862	4.23	.050138	18
43	.823114	2.35	.872998	1.88	.950116	4.25	.049884	17
44	.823255	2.37	.872885	1.88	.950371	4.23	.049629	16
45	9.823397	2.37	9.872772	1.88	9.950625	4.23	0.049375	15
46	.823539	2.35	.872659	1.87	.950879	4.23	.049121	14
47	.823680	2.35	.872547	1.88	.951133	4.25	.048867	13
48	.823821	2.37	.872434	1.88	.951388	4.23	.048612	12
49	.823963	2.35	.872321	1.88	.951642	4.23	.048358	11
50	9.824104	2.35	9.872208	1.88	9.951896	4.23	0.048104	10
51	.824245	2.35	.872095	1.90	.952150	4.25	.047850	9
52	.824386	2.35	.871981	1.88	.952405	4.23	.047595	8
53	.824527	2.35	.871868	1.88	.952659	4.23	.047341	7
54	.824668	2.35	.871755	1.90	.952913	4.23	.047087	6
55	9.824808	2.33	9.871641	1.88	9.953167	4.23	0.046833	5
56	.824949	2.35	.871528	1.90	.953421	4.23	.046579	4
57	.825090	2.35	.871414	1.88	.953675	4.23	.046325	3
58	.825230	2.33	.871301	1.90	.953929	4.23	.046071	2
59	.825371	2.35	.871187	1.90	.954183	4.23	.045817	1
60	9.825511	2.33	9.871073	1.90	9.954437	4.23	0.045563	0
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

Sin.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
9.825511	2.33	9.871073	1.88	9.954437	4.23	0.045563	60
.825651	2.33	.870960	1.90	.954691	4.25	.045309	59
.825791	2.33	.870846	1.90	.954946	4.23	.045054	58
.825931	2.33	.870732	1.90	.955200	4.23	.044800	57
.826071	2.33	.870618	1.90	.955454	4.23	.044546	56
9.826211	2.33	9.870504	1.90	9.955708	4.23	0.044292	55
.826351	2.33	.870390	1.90	.955961	4.22	.044039	54
.826491	2.33	.870276	1.90	.956215	4.23	.043785	53
.826631	2.32	.870161	1.92	.956469	4.23	.043531	52
.826770	2.33	.870047	1.90	.956723	4.23	.043277	51
9.826910	2.32	9.869933	1.92	9.956977	4.23	0.043023	50
.827049	2.33	.869818	1.90	.957231	4.23	.042769	49
.827189	2.32	.869704	1.92	.957485	4.23	.042515	48
.827328	2.32	.869589	1.92	.957739	4.23	.042261	47
.827467	2.32	.869474	1.90	.957993	4.23	.042007	46
9.827606	2.32	9.869360	1.92	9.958247	4.22	0.041753	45
.827745	2.32	.869245	1.92	.958500	4.23	.041500	44
.827884	2.32	.869130	1.92	.958754	4.23	.041246	43
.828023	2.32	.869015	1.92	.959008	4.23	.040992	42
.828162	2.32	.868900	1.92	.959262	4.23	.040738	41
9.828301	2.30	9.868785	1.92	9.959516	4.22	0.040484	40
.828439	2.32	.868670	1.92	.959769	4.23	.040231	39
.828578	2.30	.868555	1.92	.960023	4.23	.039977	38
.828716	2.32	.868440	1.92	.960277	4.23	.039723	37
.828855	2.30	.868324	1.93	.960530	4.22	.039470	36
9.828993	2.30	9.868209	1.92	9.960784	4.23	0.039216	35
.829131	2.30	.868093	1.93	.961038	4.23	.038962	34
.829269	2.30	.867978	1.92	.961292	4.23	.038708	33
.829407	2.30	.867862	1.93	.961545	4.22	.038455	32
.829545	2.30	.867747	1.92	.961799	4.23	.038201	31
9.829683	2.30	9.867631	1.93	9.962052	4.22	0.037948	30
.829821	2.30	.867515	1.93	.962306	4.23	.037694	29
.829959	2.30	.867399	1.93	.962560	4.23	.037440	28
.830097	2.28	.867283	1.93	.962813	4.22	.037187	27
.830234	2.30	.867167	1.93	.963067	4.23	.036933	26
9.830372	2.28	9.867051	1.93	9.963320	4.22	0.036680	25
.830509	2.28	.866935	1.93	.963574	4.23	.036426	24
.830646	2.28	.866819	1.93	.963828	4.23	.036172	23
.830784	2.30	.866703	1.93	.964081	4.22	.035919	22
.830921	2.28	.866586	1.95	.964335	4.23	.035665	21
9.831058	2.28	9.866470	1.93	9.964588	4.22	0.035412	20
.831195	2.28	.866353	1.95	.964842	4.23	.035158	19
.831332	2.28	.866237	1.93	.965095	4.22	.034905	18
.831469	2.28	.866120	1.95	.965349	4.23	.034651	17
.831606	2.28	.866004	1.93	.965602	4.22	.034398	16
9.831742	2.27	9.865887	1.95	9.965855	4.22	0.034145	15
.831879	2.28	.865770	1.95	.966109	4.23	.033891	14
.832015	2.27	.865653	1.95	.966362	4.22	.033638	13
.832152	2.28	.865536	1.95	.966616	4.23	.033384	12
.832288	2.27	.865419	1.95	.966869	4.22	.033131	11
9.832425	2.28	9.865302	1.95	9.967123	4.23	0.032877	10
.832561	2.27	.865185	1.95	.967376	4.22	.032624	9
.832697	2.27	.865068	1.97	.967629	4.22	.032371	8
.832833	2.27	.864950	1.95	.967883	4.23	.032117	7
.832969	2.27	.864833	1.95	.968136	4.22	.031864	6
9.833105	2.27	9.864716	1.97	9.968389	4.22	0.031611	5
.833241	2.27	.864598	1.95	.968643	4.23	.031357	4
.833377	2.25	.864481	1.97	.968896	4.22	.031104	3
.833512	2.27	.864363	1.97	.969149	4.22	.030851	2
.833648	2.25	.864245	1.97	.969403	4.23	.030597	1
9.833783		9.864127		9.969656	4.22	0.030344	0
Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

M.	Sin.	D. 1″.	Cos	D. 1″.	Tan.	D. 1″.	
0	9. 833783	2. 27	9. 864127	1. 95	9. 969656	4. 22	
1	.833919	2. 25	.864010	1. 97	.969909	4. 22	
2	.834054	2. 25	.863892	1. 97	.970162	4. 23	
3	.834189	2. 27	.863774	1. 97	.970416	4. 22	
4	.834325	2. 25	.863656	1. 97	.970669	4. 22	
5	9. 834460	2. 25	9. 863538	1. 98	9. 970922	4. 22	
6	.834595	2. 25	.863419	1. 97	.971175	4. 23	
7	.834730	2. 25	.863301	1. 97	.971429	4. 22	
8	.834865	2. 23	.863183	1. 98	.971682	4. 22	
9	.834999	2. 25	.863064	1. 97	.971935	4. 22	
10	9. 835134	2. 25	9. 862946	1. 98	9. 972188	4. 22	
11	.835269	2. 23	.862827	1. 97	.972441	4. 23	
12	.835403	2. 25	.862709	1. 98	.972695	4. 22	
13	.835538	2. 23	.862590	1. 98	.972948	4. 22	
14	.835672	2. 25	.862471	1. 97	.973201	4. 22	
15	9. 835807	2. 23	9. 862353	1. 98	9. 973454	4. 22	0.
16	.835941	2. 23	.862234	1. 98	.973707	4. 22	.
17	.836075	2. 23	.862115	1. 98	.973960	4. 22	.
18	.836209	2. 23	.861996	1. 98	.974213	4. 22	.
19	.836343	2. 23	.861877	1. 98	.974466	4. 23	.
20	9. 836477	2. 23	9. 861758	2. 00	9. 974720	4. 22	0.
21	.836611	2. 23	.861638	1. 98	.974973	4. 22	.
22	.836745	2. 22	.861519	1. 98	.975226	4. 22	.
23	.836878	2. 23	.861400	2. 00	.975479	4. 22	.
24	.837012	2. 23	.861280	1. 98	.975732	4. 22	.
25	9. 837146	2. 22	9. 861161	2. 00	9. 975985	4. 22	0.
26	.837279	2. 22	.861041	1. 98	.976238	4. 22	.
27	.837412	2. 23	.860922	2. 00	.976491	4. 22	.
28	.837546	2. 22	.860802	2. 00	.976744	4. 22	.
29	.837679	2. 22	.860682	2. 00	.976997	4. 22	.
30	9. 837812	2. 22	9. 860562	2. 00	9. 977250	4. 22	0.
31	.837945	2. 22	.860442	2. 00	.977503	4. 22	.
32	.838078	2. 22	.860322	2. 00	.977756	4. 22	.
33	.838211	2. 22	.860202	2. 00	.978009	4. 22	.
34	.838344	2. 22	.860082	2. 00	.978262	4. 22	.
35	9. 838477	2. 22	9. 859962	2. 00	9. 978515	4. 22	0.
36	.838610	2. 20	.859842	2. 02	.978768	4. 22	.
37	.838742	2. 22	.859721	2. 00	.979021	4. 22	.
38	.838875	2. 20	.859601	2. 02	.979274	4. 22	.
39	.839007	2. 22	.859480	2. 00	.979527	4. 22	.
40	9. 839140	2. 20	9. 859360	2. 02	9. 979780	4. 22	0.
41	.839272	2. 20	.859239	2. 00	.980033	4. 22	.
42	.839404	2. 20	.859119	2. 02	.980286	4. 20	.
43	.839536	2. 20	.858998	2. 02	.980538	4. 22	.
44	.839668	2. 20	.858877	2. 02	.980791	4. 22	.
45	9. 839800	2. 20	9. 858756	2. 02	9. 981044	4. 22	0.
46	.839932	2. 20	.858635	2. 02	.981297	4. 22	.
47	.840064	2. 20	.858514	2. 02	.981550	4. 22	.
48	.840196	2. 20	.858393	2. 02	.981803	4. 22	.
49	.840328	2. 18	.858272	2. 02	.982056	4. 22	.
50	9. 840459	2. 20	9. 858151	2. 03	9. 982309	4. 22	0.
51	.840591	2. 18	.858029	2. 02	.982562	4. 20	.
52	.840722	2. 20	.857908	2. 03	.982814	4. 22	.
53	.840854	2. 18	.857786	2. 02	.983067	4. 22	.
54	.840985	2. 18	.857665	2. 03	.983320	4. 22	.
55	9. 841116	2. 18	9. 857543	2. 02	9. 983573	4. 22	0.
56	.841247	2. 18	.857422	2. 03	.983826	4. 22	.
57	.841378	2. 18	.857300	2. 03	.984079	4. 22	.
58	.841509	2. 18	.857178	2. 03	.984332	4. 22	.
59	.841640	2. 18	.857056	2. 03	.984584	4. 20	.
60	9. 841771		9. 856934	2. 03	9. 984837	4. 22	0.
	Cos.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.

n.	D. 1″.	Cos.	D. 1″.	Tan.	D. 1″.	Cot.	
771	2.18	9.856934	2.03	9.984837	4.22	0.015163	60
902	2.18	.856812	2.03	.985090	4.22	.014910	59
033	2.17	.856690	2.03	.985343	4.22	.014657	58
163	2.18	.856568	2.03	.985596	4.20	.014404	57
294	2.17	.856446	2.05	.985848	4.22	.014152	56
424	2.18	9.856323	2.03	9.986101	4.22	0.013899	55
555	2.17	.856201	2.05	.986354	4.22	.013646	54
685	2.17	.856078	2.03	.986607	4.22	.013393	53
815	2.18	.855956	2.05	.986860	4.20	.013140	52
946	2.17	.855833	2.03	.987112	4.22	.012888	51
076	2.17	9.855711	2.05	9.987365	4.22	0.012635	50
206	2.17	.855588	2.05	.987618	4.22	.012382	49
336	2.17	.855465	2.05	.987871	4.20	.012129	48
466	2.15	.855342	2.05	.988123	4.22	.011877	47
595	2.17	.855219	2.05	.988376	4.22	.011624	46
725	2.17	9.855096	2.05	9.988629	4.22	0.011371	45
855	2.15	.854973	2.05	.988882	4.20	.011118	44
984	2.17	.854850	2.05	.989134	4.22	.010866	43
114	2.15	.854727	2.07	.989387	4.22	.010613	42
243	2.15	.854603	2.05	.989640	4.22	.010360	41
372	2.17	9.854480	2.07	9.989893	4.20	0.010107	40
502	2.15	.854356	2.05	.990145	4.22	.009855	39
631	2.15	.854233	2.07	.990398	4.22	.009602	38
760	2.15	.854109	2.05	.990651	4.20	.009349	37
889	2.15	.853986	2.07	.990903	4.22	.009097	36
018	2.15	9.853862	2.07	9.991156	4.22	0.008844	35
147	2.15	.853738	2.07	.991409	4.22	.008591	34
276	2.15	.853614	2.07	.991662	4.20	.008338	33
405	2.13	.853490	2.07	.991914	4.22	.008086	32
533	2.15	.853366	2.07	.992167	4.22	.007833	31
662	2.13	9.853242	2.07	9.992420	4.20	0.007580	30
790	2.15	.853118	2.07	.992672	4.22	.007328	29
919	2.13	.852994	2.08	.992925	4.22	.007075	28
047	2.13	.852869	2.07	.993178	4.22	.006822	27
175	2.13	.852745	2.08	.993431	4.20	.006569	26
304	2.15	9.852620	2.07	9.993683	4.22	0.006317	25
432	2.13	.852496	2.08	.993936	4.22	.006064	24
560	2.13	.852371	2.07	.994189	4.20	.005811	23
688	2.13	.852247	2.08	.994441	4.22	.005559	22
816	2.13	.852122	2.08	.994694	4.22	.005306	21
944	2.12	9.851997	2.08	9.994947	4.20	0.005053	20
071	2.13	.851872	2.08	.995199	4.22	.004801	19
199	2.13	.851747	2.08	.995452	4.22	.004548	18
327	2.12	.851622	2.08	.995705	4.20	.004295	17
454	2.13	.851497	2.08	.995957	4.22	.004043	16
582	2.12	9.851372	2.10	9.996210	4.22	0.003790	15
709	2.12	.851246	2.08	.996463	4.20	.003537	14
836	2.13	.851121	2.08	.996715	4.22	.003285	13
964	2.12	.850996	2.10	.996968	4.22	.003032	12
091	2.12	.850870	2.08	.997221	4.20	.002779	11
218	2.12	9.850745	2.10	9.997473	4.22	0.002527	10
345	2.12	.850619	2.10	.997726	4.22	.002274	9
472	2.12	.850493	2.08	.997979	4.20	.002021	8
599	2.12	.850368	2.10	.998231	4.22	.001769	7
726	2.10	.850242	2.10	.998484	4.22	.001516	6
852	2.12	9.850116	2.10	9.998737	4.20	0.001263	5
979	2.12	.849990	2.10	.998989	4.22	.001011	4
106	2.10	.849864	2.10	.999242	4.22	.000758	3
232	2.12	.849738	2.12	.999495	4.20	.000505	2
359	2.10	.849611	2.10	.999747	4.22	.000253	1
485		9.849485		0.000000		0.000000	0
s.	D. 1″.	Sin.	D. 1″.	Cot.	D. 1″.	Tan.	M.

45°

0°				1°			2°		
M.	S.	Sin.	Tan.	S.	Sin.	Tan.	S.	Sin.	Ta
		4.68			4.68			4.68	
0	0	5575	5575	3600	5553	5619	7200	5487	575
1	60	5575	5575	3660	5552	5620	7260	5485	575
2	120	5575	5575	3720	5551	5622	7320	5484	575
3	180	5575	5575	3780	5551	5623	7380	5482	576
4	240	5575	5575	3840	5550	5625	7440	5481	576
5	300	5575	5575	3900	5549	5627	7500	5479	576
6	360	5575	5575	3960	5548	5628	7560	5478	576
7	420	5575	5575	4020	5547	5630	7620	5476	577
8	480	5574	5576	4080	5547	5632	7680	5475	577
9	540	5574	5576	4140	5546	5633	7740	5473	577
10	600	5574	5576	4200	5545	5635	7800	5471	578
11	660	5574	5576	4260	5544	5637	7860	5470	578
12	720	5574	5577	4320	5543	5638	7920	5468	578
13	780	5574	5577	4380	5542	5640	7980	5467	579
14	840	5574	5577	4440	5541	5642	8040	5465	579
15	900	5573	5578	4500	5540	5644	8100	5463	579
16	960	5573	5578	4560	5539	5646	8160	5462	580
17	1020	5573	5578	4620	5539	5648	8220	5460	580
18	1080	5573	5579	4680	5538	5649	8280	5458	580
19	1140	5573	5579	4740	5537	5651	8340	5457	581
20	1200	5572	5580	4800	5536	5653	8400	5455	581
21	1260	5572	5580	4860	5535	5655	8460	5453	581
22	1320	5572	5581	4920	5534	5657	8520	5451	582
23	1380	5572	5581	4980	5533	5659	8580	5450	582
24	1440	5571	5582	5040	5532	5661	8640	5448	582
25	1500	5571	5583	5100	5531	5663	8700	5446	583
26	1560	5571	5583	5160	5530	5665	8760	5444	583
27	1620	5570	5584	5220	5529	5668	8820	5443	584
28	1680	5570	5584	5280	5527	5670	8880	5441	584
29	1740	5570	5585	5340	5526	5672	8940	5439	584
30	1800	5569	5586	5400	5525	5674	9000	5437	585
31	1860	5569	5587	5460	5524	5676	9060	5435	585
32	1920	5569	5587	5520	5523	5679	9120	5433	585
33	1980	5568	5588	5580	5522	5681	9180	5431	586
34	2040	5568	5589	5640	5521	5683	9240	5430	586
35	2100	5567	5590	5700	5520	5685	9300	5428	586
36	2160	5567	5591	5760	5518	5688	9360	5426	587
37	2220	5566	5592	5820	5517	5690	9420	5424	587
38	2280	5566	5593	5880	5516	5693	9480	5422	588
39	2340	5566	5593	5940	5515	5695	9540	5420	588
40	2400	5565	5594	6000	5514	5697	9600	5418	588
41	2460	5565	5595	6060	5512	5700	9660	5416	589
42	2520	5564	5596	6120	5511	5702	9720	5414	589
43	2580	5564	5598	6180	5510	5705	9780	5412	590
44	2640	5563	5599	6240	5509	5707	9840	5410	590
45	2700	5562	5600	6300	5507	5710	9900	5408	590
46	2760	5562	5601	6360	5506	5713	9960	5406	591
47	2820	5561	5602	6420	5505	5715	10020	5404	591
48	2880	5561	5603	6480	5503	5718	10080	5402	592
49	2940	5560	5604	6540	5502	5720	10140	5400	592
50	3000	5560	5605	6600	5501	5723	10200	5398	592
51	3060	5559	5607	6660	5499	5726	10260	5396	593
52	3120	5558	5608	6720	5498	5729	10320	5394	593
53	3180	5558	5609	6780	5497	5731	10380	5392	594
54	3240	5557	5611	6840	5495	5734	10440	5389	594
55	3300	5556	5612	6900	5494	5737	10500	5387	595
56	3360	5556	5613	6960	5492	5740	10560	5385	595
57	3420	5555	5615	7020	5491	5743	10620	5383	595
58	3480	5554	5616	7080	5490	5745	10680	5381	596
59	3540	5554	5618	7140	5488	5748	10740	5379	596
60	3600	5553	5619	7200	5487	5751	10800	5376	597
M.	S.	Sin.	Tan.	S.	Sin.	Tan.	S.	Sin.	Tan

3°			4°			5°			
	Sin.	Tan.	S.	Sin.	Tan.	S.	Sin.	Tan.	M.
	4.68			4.68			4.68		
10	5376	5972	14400	5222	6281	18000	5024	6679	0
10	5374	5976	14460	5219	6287	18060	5020	6687	1
10	5372	5981	14520	5216	6293	18120	5016	6694	2
10	5370	5985	14580	5213	6299	18180	5012	6702	3
10	5367	5990	14640	5210	6305	18240	5009	6709	4
10	5365	5994	14700	5207	6311	18300	5005	6716	5
10	5363	5999	14760	5204	6317	18360	5001	6724	6
10	5361	6004	14820	5201	6323	18420	4997	6732	7
10	5358	6008	14880	5198	6329	18480	4994	6739	8
10	5356	6013	14940	5195	6335	18540	4990	6747	9
10	5354	6017	15000	5192	6341	18600	4986	6754	10
10	5351	6022	15060	5189	6348	18660	4982	6762	11
10	5349	6027	15120	5186	6354	18720	4978	6770	12
10	5347	6031	15180	5183	6360	18780	4975	6777	13
10	5344	6036	15240	5180	6366	18840	4971	6785	14
10	5342	6041	15300	5177	6372	18900	4967	6793	15
10	5340	6046	15360	5173	6379	18960	4963	6800	16
10	5337	6051	15420	5170	6385	19020	4959	6808	17
10	5335	6055	15480	5167	6391	19080	4955	6816	18
10	5332	6060	15540	5164	6398	19140	4951	6824	19
10	5330	6065	15600	5161	6404	19200	4948	6832	20
10	5327	6070	15660	5158	6410	19260	4944	6840	21
10	5325	6075	15720	5154	6417	19320	4940	6848	22
10	5322	6080	15780	5151	6423	19380	4936	6855	23
10	5320	6085	15840	5148	6430	19440	4932	6863	24
10	5317	6090	15900	5145	6436	19500	4928	6871	25
10	5315	6095	15960	5141	6443	19560	4924	6879	26
10	5312	6100	16020	5138	6449	19620	4920	6887	27
10	5310	6105	16080	5135	6456	19680	4916	6896	28
10	5307	6110	16140	5132	6463	19740	4912	6904	29
10	5305	6116	16200	5128	6469	19800	4908	6912	30
10	5302	6121	16260	5125	6476	19860	4904	6920	31
10	5300	6126	16320	5122	6482	19920	4900	6928	32
10	5297	6131	16380	5118	6489	19980	4895	6936	33
10	5294	6136	16440	5115	6496	20040	4891	6944	34
10	5292	6142	16500	5112	6503	20100	4887	6953	35
10	5289	6147	16560	5108	6509	20160	4883	6961	36
10	5286	6152	16620	5105	6516	20220	4880	6969	37
10	5284	6158	16680	5101	6523	20280	4875	6977	38
10	5281	6163	16740	5098	6530	20340	4871	6986	39
10	5278	6168	16800	5095	6537	20400	4867	6994	40
10	5276	6174	16860	5091	6544	20460	4862	7003	41
10	5273	6179	16920	5088	6551	20520	4858	7011	42
10	5270	6185	16980	5084	6557	20580	4854	7019	43
10	5268	6190	17040	5081	6564	20640	4850	7028	44
10	5265	6196	17100	5077	6571	20700	4846	7036	45
10	5262	6201	17160	5074	6578	20760	4841	7045	46
10	5259	6207	17220	5070	6585	20820	4837	7053	47
10	5256	6212	17280	5067	6593	20880	4833	7062	48
10	5254	6218	17340	5063	6600	20940	4829	7070	49
10	5251	6224	17400	5060	6607	21000	4824	7079	50
10	5248	6229	17460	5056	6614	21060	4820	7088	51
20	5245	6235	17520	5053	6621	21120	4816	7096	52
30	5242	6241	17580	5049	6628	21180	4811	7105	53
40	5239	6246	17640	5045	6635	21240	4807	7114	54
50	5237	6252	17700	5042	6643	21300	4803	7122	55
50	5234	6258	17760	5038	6650	21360	4798	7131	56
20	5231	6264	17820	5034	6657	21420	4794	7140	57
0	5228	6269	17880	5031	6665	21480	4790	7149	58
	5225	6275	17940	5027	6672	21540	4785	7158	59
	5222	6281	18000		6679	21600	4781	7166	60
	Sin.	Tan.				S.	Sin.	Tan.	M.

0°					1°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D.
0	∞		∞		0	6. 182714	239. 28	6. 182780	239.
1	2. 626422	10034. 33	2. 626422	10034. 33	1	.197071	235. 38	.197139	235.
2	3. 228482	5869. 72	3. 228482	5869. 72	2	.211194	231. 62	.211264	231.
3	.580665	4164. 62	.580665	4164. 62	3	.225091	227. 98	.225164	228.
4	.830542	3230. 33	.830542	3230. 35	4	.238770	224. 43	.238845	224.
5	4. 024362	2639. 38	4. 024363	2639. 37	5	6. 252236	221. 02	6. 252314	221.
6	.182725	2231. 55	.182725	2231. 57	6	.265497	217. 68	.265577	217.
7	.316618	1933. 07	.316619	1933. 07	7	.278558	214. 47	.278641	214.
8	.432602	1705. 08	.432603	1705. 08	8	.291426	211. 33	.291511	211.
9	.534907	1525. 25	.534908	1525. 27	9	.304106	208. 28	.304193	208.
10	4. 626422	1379. 75	4. 626424	1379. 75	10	6. 316603	205. 33	6. 316693	205.
11	.709207	1259. 62	.709209	1259. 63	11	.328923	202. 47	.329016	202.
12	.784784	1158. 73	.784787	1158. 75	12	.341071	199. 68	.341167	199.
13	.854308	1072. 83	.854312	1072. 82	13	.353052	196. 95	.353150	197.
14	.918678	998. 77	.918681	998. 78	14	.364869	194. 32	.364970	194.
15	4. 978604	934. 28	4. 978608	934. 30	15	6. 376528	191. 73	6. 376631	191.
16	5. 034661	877. 63	5. 034666	877. 65	16	.388032	189. 23	.388138	189.
17	.087319	827. 45	.087325	827. 45	17	.399386	186. 78	.399494	186.
18	.136966	782. 70	.136972	782. 72	18	.410593	184. 40	.410705	184.
19	.183928	742. 55	.183935	742. 55	19	.421657	182. 10	.421772	182.
20	5. 228481	706. 30	5. 228488	706. 33	20	6. 432583	179. 82	6. 432700	179.
21	.270859	673. 45	.270868	673. 45	21	.443372	177. 62	.443493	177.
22	.311266	643. 50	.311275	643. 52	22	.454029	175. 47	.454153	175.
23	.349876	616. 12	.349886	616. 13	23	.464557	173. 37	.464684	175.
24	.386843	590. 95	.386854	590. 97	24	.474959	171. 32	.475089	171.
25	5. 422300	567. 78	5. 422312	567. 78	25	6. 485238	169. 30	6. 485371	169.
26	.456367	546. 35	.456379	546. 37	26	.495396	167. 37	.495532	167.
27	.489148	526. 47	.489161	526. 48	27	.505438	165. 43	.505577	165.
28	.520736	508. 00	.520750	508. 02	28	.515364	163. 57	.515506	163.
29	.551216	490. 77	.551231	490. 80	29	.525178	161. 73	.525324	161.
30	5. 580662	474. 68	5. 580679	474. 68	30	6. 534882	159. 97	6. 535031	160.
31	.609143	459. 60	.609160	459. 63	31	.544480	158. 20	.544632	158.
32	.636719	445. 47	.636738	445. 48	32	.553972	156. 50	.554128	156.
33	.663447	432. 17	.663467	432. 18	33	.563362	154. 82	.563521	154.
34	.689377	419. 63	.689398	419. 65	34	.572651	153. 18	.572813	153.
35	5. 714555	407. 80	5. 714577	407. 83	35	6. 581842	151. 57	6. 582008	151.
36	.739023	396. 63	.739047	396. 67	36	.590936	150. 02	.591106	150.
37	.762821	386. 07	.762847	386. 08	37	.599937	148. 47	.600110	148.
38	.785985	376. 03	.786012	376. 05	38	.608845	146. 97	.609021	147.
39	.808547	366. 50	.808575	366. 53	39	.617663	145. 48	.617843	145.
40	5. 830537	357. 47	5. 830567	357. 48	40	6. 626392	144. 03	6. 626575	144.
41	.851985	348. 83	.852016	348. 87	41	.635034	142. 62	.635221	142.
42	.872915	340. 63	.872948	340. 65	42	.643591	141. 22	.643782	141.
43	.893353	332. 82	.893387	332. 83	43	.652064	139. 87	.652259	139.
44	.913322	325. 32	.913357	325. 35	44	.660456	138. 52	.660655	138.
45	5. 932841	318. 17	5. 932878	318. 20	45	6. 668767	137. 22	6. 668970	137.
46	.951931	311. 33	.951970	311. 37	46	.677000	135. 92	.677206	135.
47	.970611	304. 78	.970652	304. 80	47	.685155	134. 65	.685365	134.
48	.988898	298. 48	.988940	298. 52	48	.693234	133. 42	.693448	133.
49	6. 006807	292. 47	6. 006851	292. 50	49	.701239	132. 20	.701457	132.
50	6. 024355	286. 67	6. 024401	286. 68	50	6. 709171	130. 98	6. 709393	131.
51	.041555	281. 10	.041602	281. 13	51	.717030	129. 82	.717257	129.
52	.058421	275. 73	.058470	275. 78	52	.724820	128. 67	.725050	128.
53	.074965	270. 60	.075017	270. 62	53	.732540	127. 53	.732775	127.
54	.091201	265. 62	.091254	265. 67	54	.740192	126. 42	.740431	126.
55	6. 107138	260. 85	6. 107194	260. 87	55	6. 747777	125. 33	6. 748020	125.
56	.122789	256. 22	.122846	256. 27	56	.755297	124. 25	.755544	124.
57	.138162	251. 77	.138222	251. 80	57	.762752	123. 20	.763004	123.
58	.153268	247. 47	.153330	247. 50	58	.770144	122. 15	.770400	122.
59	.168116	243. 30	.168180	243. 33	59	.777473	121. 13	.777733	121.
60	6. 182714		6. 182780		60	6. 784741		6. 785005	

2°				3°				
Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
.784741	120. 12	6. 785005	120. 20	0	7. 136868	80. 18	7. 137464	80. 28
.791948	119. 13	.792217	119. 22	1	.141679	79. 75	.142281	79. 85
.799096	118. 17	.799370	118. 23	2	.146464	79. 30	.147072	79. 42
.806186	117. 22	.806464	117. 28	3	.151222	78. 87	.151837	79. 00
.813219	116. 25	.813501	116. 35	4	.155954	78. 45	.156577	78. 55
.820194	115. 35	6. 820482	115. 40	5	7. 160661	78. 02	7. 161290	78. 13
.827115	114. 42	.827406	114. 52	6	.165342	77. 60	.165978	77. 72
.833980	113. 53	.834277	113. 60	7	.169998	77. 20	.170641	77. 30
.840792	112. 65	.841093	112. 73	8	.174630	76. 77	.175279	76. 90
.847551	111. 77	.847857	111. 85	9	.179236	76. 38	.179893	76. 50
.854257	110. 92	6. 854568	111. 00	10	7. 183819	75. 97	7. 184483	76. 08
.860912	110. 08	.861228	110. 15	11	.188377	75. 58	.189048	75. 68
.867517	109. 23	.867837	109. 32	12	.192912	75. 18	.193589	75. 32
.874071	108. 43	.874396	108. 52	13	.197423	74. 78	.198108	74. 90
.880577	107. 62	.880907	107. 70	14	.201910	74. 42	.202602	74. 53
.887034	106. 82	6. 887369	106. 90	15	7. 206375	74. 03	7. 207074	74. 15
.893443	106. 05	.893783	106. 13	16	.210817	73. 65	.211523	73. 77
.899806	105. 27	.900151	105. 35	17	.215236	73. 28	.215949	73. 40
.906122	104. 52	.906472	104. 60	18	.219633	72. 90	.220353	73. 03
.912393	103. 75	.912748	103. 85	19	.224007	72. 55	.224735	72. 67
.918618	103. 03	6. 918979	103. 10	20	7. 228360	72. 18	7. 229095	72. 30
.924800	102. 28	.925165	102. 38	21	.232691	71. 82	.233433	71. 95
.930937	101. 58	.931308	101. 67	22	.237000	71. 47	.237750	71. 60
.937032	100. 87	.937408	100. 95	23	.241288	71. 12	.242046	71. 23
.943084	100. 17	.943465	100. 25	24	.245555	70. 77	.246320	70. 90
.949094	99. 48	6. 949480	99. 57	25	7. 249801	70. 43	7. 250574	70. 55
.955063	98. 80	.955454	98. 90	26	.254027	70. 08	.254807	70. 20
.960991	98. 13	.961388	98. 22	27	.258232	69. 73	.259019	69. 88
.966879	97. 47	.967281	97. 57	28	.262416	69. 42	.263212	69. 53
.972727	96. 82	.973135	96. 90	29	.266581	69. 08	.267384	69. 22
.978536	96. 17	6. 978949	96. 27	30	7. 270726	68. 75	7. 271537	68. 87
.984306	95. 55	.984725	95. 63	31	.274851	68. 42	.275669	68. 57
.990039	94. 90	.990463	95. 02	32	.278956	68. 12	.279783	68. 23
.995733	94. 30	.996164	94. 38	33	.283043	67. 78	.283877	67. 92
1.001391	93. 68	7. 001827	93. 78	34	.287110	67. 47	.287952	67. 58
1.007012	93. 08	7. 007454	93. 17	35	7. 291158	67. 15	7. 292007	67. 30
1.012597	92. 48	.013044	92. 58	36	.295187	66. 83	.296045	66. 97
1.018146	91. 90	.018599	92. 00	37	.299197	66. 55	.300063	66. 67
1.023660	91. 32	.024119	91. 42	38	.303190	66. 23	.304063	66. 37
1.029139	90. 75	.029604	90. 83	39	.307164	65. 92	.308045	66. 07
1.034584	90. 18	7. 035054	90. 28	40	7. 311119	65. 63	7. 312009	65. 77
1.039995	89. 62	.040471	89. 72	41	.315057	65. 33	.315955	65. 47
1.045372	89. 07	.045854	89. 17	42	.318977	65. 05	.319883	65. 18
1.050716	88. 53	.051204	88. 63	43	.322880	64. 75	.323794	64. 88
1.056028	87. 98	.056522	88. 08	44	.326765	64. 45	.327687	64. 60
1.061307	87. 45	7. 061807	87. 57	45	7. 330632	64. 18	7. 331563	64. 32
1.066554	86. 93	.067061	87. 02	46	.334483	63. 88	.335422	64. 03
1.071770	86. 40	.072282	86. 52	47	.338316	63. 62	.339264	63. 75
1.076954	85. 90	.077473	86. 00	48	.342133	63. 33	.343089	63. 47
1.082108	85. 40	.082633	85. 50	49	.345933	63. 05	.346897	63. 20
1.087232	84. 88	7. 087763	84. 98	50	7. 349716	62. 78	7. 350689	62. 92
1.092325	84. 40	.092862	84. 50	51	.353483	62. 50	.354464	62. 65
1.097389	83. 90	.097932	84. 02	52	.357233	62. 25	.358223	62. 38
1.102423	83. 42	.102973	83. 53	53	.360968	61. 97	.361966	62. 12
1.107428	82. 95	.107985	83. 05	54	.364686	61. 72	.365693	61. 85
1.112405	82. 47	7. 112968	82. 57	55	7. 368389	61. 45	7. 369404	61. 60
1.117353	82. 00	.117922	82. 12	56	.372076	61. 18	.373100	61. 33
1.122273	81. 53	.122849	81. 65	57	.375747	60. 93	.376780	61. 07
1.127165	81. 08	.127748	81. 18	58	.379403	60. 67	.380444	60. 83
1.132030	80. 63	.132619	80. 75	59	.383043	60. 42	.384094	60. 57
		7. 137464		60	7. 386668		7. 387728	

0°					1°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	
0	∞		∞		0	6.182714		6
1	2.626422		2.626422		1	.197071	239.28	
2	3.228482	10034.33	3.228482	10034.33	2	.211194	235.38	
3	.580665	5869.72	.580665	5869.72	3	.225091	231.62	
4	.830542	4164.62	.830542	4164.62	4	.238770	227.98	
5	4.024362	3230.33	4.024363	3230.35	5	6.252236	224.43	6
6	.182725	2639.38	.182725	2639.37	6	.265497	221.02	
7	.316618	2231.55	.316619	2231.57	7	.278558	217.68	
8	.432602	1933.07	.432603	1933.07	8	.291426	214.47	
9	.534907	1705.08	.534908	1705.08	9	.304106	211.33	
		1525.25		1525.27			208.28	
10	4.626422		4.626424		10	6.316603		6
11	.709207	1379.75	.709209	1379.75	11	.328923	205.33	
12	.784784	1259.62	.784787	1259.63	12	.341071	202.47	
13	.854308	1158.73	.854312	1158.75	13	.353052	199.68	
14	.918678	1072.83	.918681	1072.82	14	.364869	196.95	
15	4.978604	998.77	4.978608	998.78	15	6.376528	194.32	6
16	5.034661	934.28	5.034666	934.30	16	.388032	191.73	
17	.087319	877.63	.087325	877.65	17	.399386	189.23	
18	.136966	827.45	.136972	827.45	18	.410593	186.78	
19	.183928	782.70	.183935	782.72	19	.421657	184.40	
		742.55		742.55			182.10	
20	5.228481		5.228488		20	6.432583		6
21	.270859	706.30	.270868	706.33	21	.443372	179.82	
22	.311266	673.45	.311275	673.45	22	.454029	177.62	
23	.349876	643.50	.349886	643.52	23	.464557	175.47	
24	.386843	616.12	.386854	616.13	24	.474959	173.37	
25	5.422300	590.95	5.422312	590.97	25	6.485238	171.32	6
26	.456367	567.78	.456379	567.78	26	.495396	169.30	
27	.489148	546.35	.489161	546.37	27	.505438	167.37	
28	.520736	526.47	.520750	526.48	28	.515364	165.43	
29	.551216	508.00	.551231	508.02	29	.525178	163.57	
		490.77		490.80			161.73	
30	5.580662		5.580679		30	6.534882		6
31	.609143	474.68	.609160	474.68	31	.544480	159.97	
32	.636719	459.60	.636738	459.63	32	.553972	158.20	
33	.663447	445.47	.663467	445.48	33	.563362	156.50	
34	.689377	432.17	.689398	432.18	34	.572651	154.82	
35	5.714555	419.63	5.714577	419.65	35	6.581842	153.18	6
36	.739023	407.80	.739047	407.83	36	.590936	151.57	
37	.762821	396.63	.762847	396.67	37	.599937	150.02	
38	.785985	386.07	.786012	386.08	38	.608845	148.47	
39	.808547	376.03	.808575	376.05	39	.617663	146.97	
		366.50		366.53			145.48	
40	5.830537		5.830567		40	6.626392		6
41	.851985	357.47	.852016	357.48	41	.635034	144.03	
42	.872915	348.83	.872948	348.87	42	.643591	142.62	
43	.893353	340.63	.893387	340.65	43	.652064	141.22	
44	.913322	332.82	.913357	332.83	44	.660456	139.87	
45	5.932841	325.32	5.932878	325.35	45	6.668767	138.52	6
46	.951931	318.17	.951970	318.20	46	.677000	137.22	
47	.970611	311.33	.970652	311.37	47	.685155	135.92	
48	.988898	304.78	.988940	304.80	48	.693234	134.65	
49	6.006807	298.48	6.006851	298.52	49	.701239	133.42	
		292.47		292.50			132.20	
50	6.024355		6.024401		50	6.709171		6
51	.041555	286.67	.041602	286.68	51	.717030	130.98	
52	.058421	281.10	.058470	281.13	52	.724820	129.82	
53	.074965	275.73	.075017	275.78	53	.732540	128.67	
54	.091201	270.60	.091254	270.62	54	.740192	127.53	
55	6.107138	265.62	6.107194	265.67	55	6.747777	126.42	6
56	.122789	260.85	.122846	260.87	56	.755297	125.33	
57	.138162	256.22	.138222	256.27	57	.762752	124.25	
58	.153268	251.77	.153330	251.80	58	.770144	123.20	
59	.168116	247.47	.168180	247.50	59	.777473	122.15	
60	6.182714	243.30	6.182780	243.33	60	6.784741	121.1	

′	2° D.1″.	Exsec.	D.1″.
41	120.12	6.785005	120.20
48	119.13	.792217	119.22
56	118.17	.799370	118.23
56	117.22	.806464	117.28
19	116.25	.813501	116.35
54	115.35	6.820482	115.40
15	114.42	.827406	114.52
30	113.53	.834277	113.60
52	112.65	.841093	112.73
51	111.77	.847857	111.85
57	110.92	6.854568	111.00
12	110.08	.861228	110.15
17	109.23	.867837	109.32
71	108.43	.874396	108.52
77	107.62	.880907	107.70
34	106.82	6.887369	106.90
43	106.05	.893783	106.13
06	105.27	.900151	105.35
22	104.52	.906472	104.60
93	103.75	.912748	103.85
18	103.03	6.918979	103.10
00	102.28	.925165	102.38
37	101.58	.931308	101.67
32	100.87	.937408	100.95
84	100.17	.943465	100.25
94	99.48	6.949480	99.57
63	98.80	.955454	98.90
91	98.13	.961388	98.22
79	97.47	.967281	97.57
27	96.82	.973135	96.90
36	96.17	6.978949	96.27
06	95.55	.984725	95.63
39	94.90	.990463	95.02
33	94.30	.996164	94.38
91	93.68	7.001827	93.78
12	93.08	7.007454	93.17
97	92.48	.013044	92.58
46	91.90	.018599	92.00
60	91.32	.024119	91.42
39	90.75	.029604	90.83
84	90.18	7.035054	90.28
95	89.62	.040471	89.72
72	89.07	.045854	89.17
16	88.53	.051204	88.63
28	87.98	.056522	88.08
07	87.45	7.061807	87.57
54	86.93	.067061	87.02
70	86.40	.072282	86.52
54	85.90	.077473	86.00
08	85.40	.082633	85.50
32	84.88	7.087763	84.98
25	84.40	.092862	84.50
89	83.90	.097932	84.02
23	83.42	.102973	83.53
28	82.95	.107985	83.05
05	82.47	7.112968	82.57
53	82.00	.117922	82.12
73	81.53	.122849	81.65
25	81.08	.127748	81.18
2	80.63	.132619	80.75
		7.137464	

′	3° M.	Vers.	D.1″.	Exsec.	D.1″.
	0	7.136868	80.18	7.137464	80.28
	1	.141679	79.75	.142281	79.85
	2	.146464	79.30	.147072	79.42
	3	.151222	78.87	.151837	79.00
	4	.155954	78.45	.156577	78.55
	5	7.160661	78.02	7.161290	78.13
	6	.165342	77.60	.165978	77.72
	7	.169998	77.20	.170641	77.30
	8	.174630	76.77	.175279	76.90
	9	.179236	76.38	.179893	76.50
	10	7.183819	75.97	7.184483	76.08
	11	.188377	75.58	.189048	75.68
	12	.192912	75.18	.193589	75.32
	13	.197423	74.78	.198108	74.90
	14	.201910	74.42	.202602	74.53
	15	7.206375	74.03	7.207074	74.15
	16	.210817	73.65	.211523	73.77
	17	.215236	73.28	.215949	73.40
	18	.219633	72.90	.220353	73.03
	19	.224007	72.55	.224735	72.67
	20	7.228360	72.18	7.229095	72.30
	21	.232691	71.82	.233433	71.95
	22	.237000	71.47	.237750	71.60
	23	.241288	71.12	.242046	71.23
	24	.245555	70.77	.246320	70.90
	25	7.249801	70.43	7.250574	70.55
	26	.254027	70.08	.254807	70.20
	27	.258232	69.73	.259019	69.88
	28	.262416	69.42	.263212	69.53
	29	.266581	69.08	.267384	69.22
	30	7.270726	68.75	7.271537	68.87
	31	.274851	68.42	.275669	68.57
	32	.278956	68.12	.279783	68.23
	33	.283043	67.78	.283877	67.92
	34	.287110	67.47	.287952	67.58
	35	7.291158	67.15	7.292007	67.30
	36	.295187	66.83	.296045	66.97
	37	.299197	66.55	.300063	66.67
	38	.303190	66.23	.304063	66.37
	39	.307164	65.92	.308045	66.07
	40	7.311119	65.63	7.312009	65.77
	41	.315057	65.33	.315955	65.47
	42	.318977	65.05	.319883	65.18
	43	.322880	64.75	.323794	64.88
	44	.326765	64.45	.327687	64.60
	45	7.330632	64.18	7.331563	64.32
	46	.334483	63.88	.335422	64.03
	47	.338316	63.62	.339264	63.75
	48	.342133	63.33	.343089	63.47
	49	.345933	63.05	.346897	63.20
	50	7.349716	62.78	7.350689	62.92
	51	.353483	62.50	.354464	62.65
	52	.357233	62.25	.358223	62.38
	53	.360968	61.97	.361966	62.12
	54	.364686	61.72	.365693	61.85
	55	7.368389	61.45	7.369404	61.60
	56	.372076	61.18	.373100	61.33
	57	.375747	60.93	.376780	61.07
	58	.379403	60.67	.380444	60.83
	59	.383043	60.42	.384094	60.57
	60	7.386668		7.387728	

8°					9°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	E
0	7.988199	30.08	7.992446	30.38	0	8.090317	26.72	8.
1	.990004	30.02	.994269	30.32	1	.091920	26.68	.
2	.991805	29.95	.996088	30.25	2	.093521	26.63	.
3	.993602	29.88	.997903	30.18	3	.095119	26.58	.
4	.995395	29.83	.999714	30.13	4	.096714	26.52	.
5	7.997185	29.77	8.001522	30.07	5	8.098305	26.48	8.
6	.998971	29.72	.003326	30.00	6	.099894	26.43	.
7	8.000754	29.63	.005126	29.95	7	.101480	26.40	.
8	.002532	29.60	.006923	29.88	8	.103064	26.33	.
9	.004308	29.52	.008716	29.83	9	.104644	26.28	.
10	8.006079	29.47	8.010506	29.77	10	8.106221	26.25	8.
11	.007847	29.40	.012292	29.70	11	.107796	26.18	.
12	.009611	29.35	.014074	29.65	12	.109367	26.15	.
13	.011372	29.28	.015853	29.58	13	.110936	26.10	.
14	.013129	29.22	.017628	29.53	14	.112502	26.05	.
15	8.014882	29.17	8.019400	29.47	15	8.114065	26.00	8.
16	.016632	29.10	.021168	29.42	16	.115625	25.95	.
17	.018378	29.05	.022933	29.35	17	.117182	25.92	.
18	.020121	29.00	.024694	29.30	18	.118737	25.87	.
19	.021861	28.93	.026452	29.23	19	.120289	25.82	.
20	8.023597	28.87	8.028206	29.18	20	8.121838	25.77	8.
21	.025329	28.82	.029957	29.13	21	.123384	25.72	.
22	.027058	28.75	.031705	29.07	22	.124927	25.68	.
23	.028783	28.70	.033449	29.00	23	.126468	25.63	.
24	.030505	28.65	.035189	28.97	24	.128006	25.58	.
25	8.032224	28.58	8.036927	28.90	25	8.129541	25.55	8.
26	.033939	28.53	.038661	28.83	26	.131074	25.50	.
27	.035651	28.47	.040391	28.78	27	.132604	25.45	.
28	.037359	28.42	.042118	28.73	28	.134131	25.40	.
29	.039064	28.37	.043842	28.68	29	.135655	25.37	.
30	8.040766	28.30	8.045563	28.62	30	8.137177	25.32	8.
31	.042464	28.25	.047280	28.57	31	.138696	25.27	.
32	.044159	28.20	.048994	28.50	32	.140212	25.23	.
33	.045851	28.13	.050704	28.47	33	.141726	25.18	.
34	.047539	28.08	.052412	28.40	34	.143237	25.13	.
35	8.049224	28.03	8.054116	28.35	35	8.144745	25.10	8.
36	.050906	27.98	.055817	28.28	36	.146251	25.05	.
37	.052585	27.92	.057514	28.25	37	.147754	25.02	.
38	.054260	27.87	.059209	28.18	38	.149255	24.95	.
39	.055932	27.82	.060900	28.13	39	.150752	24.93	.
40	8.057601	27.75	8.062588	28.08	40	8.152248	24.88	8.
41	.059266	27.72	.064273	28.03	41	.153741	24.83	.
42	.060929	27.65	.065955	27.97	42	.155231	24.78	.
43	.062588	27.60	.067633	27.93	43	.156718	24.75	.
44	.064244	27.55	.069309	27.87	44	.158203	24.72	.
45	8.065897	27.48	8.070981	27.82	45	8.159686	24.67	8.
46	.067546	27.45	.072650	27.77	46	.161166	24.62	.
47	.069193	27.38	.074316	27.72	47	.162643	24.58	.
48	.070836	27.33	.075979	27.67	48	.164118	24.53	.
49	.072476	27.30	.077639	27.60	49	.165590	24.50	.
50	8.074114	27.23	8.079295	27.57	50	8.167060	24.45	8.
51	.075748	27.18	.080949	27.52	51	.168527	24.42	.
52	.077379	27.13	.082600	27.45	52	.169992	24.37	.
53	.079007	27.07	.084247	27.42	53	.171454	24.33	.
54	.080631	27.03	.085892	27.37	54	.172914	24.30	.
55	8.082253	26.98	8.087534	27.30	55	8.174372	24.25	8.
56	.083872	26.93	.089172	27.27	56	.175827	24.20	.
57	.085488	26.87	.090808	27.20	57	.177279	24.17	.
58	.087100	26.83	.092440	27.17	58	.178729	24.13	.
59	.088710	26.78	.094070	27.12	59	.180177	24.08	.
60	8.090317		8.095697		60	8.181622		8.

6°			7°				
D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
	7.741016		0	7.872381		7.875630	
40. 13	.743436	40. 33	1	.874444	34. 38	.877708	34. 63
40. 00	.745850	40. 23	2	.876502	34. 30	.879782	34. 57
39. 90	.748258	40. 13	3	.878555	34. 22	.881851	34. 48
39. 78	.750658	40. 00	4	.880603	34. 13	.883915	34. 40
39. 68	7.753052	39. 90	5	7.882647	34. 07	7.885974	34. 32
39. 57	.755440	39. 80	6	.884686	33. 98	.888029	34. 25
39. 47	.757821	39. 68	7	.886720	33. 90	.890078	34. 15
39. 35	.760196	39. 58	8	.888749	33. 82	.892123	34. 08
39. 25	.762565	39. 48	9	.890773	33. 73	.894164	34. 02
39. 13		39. 37			33. 67		33. 92
	7.764927		10	7.892793		7.896199	
39. 05	.767282	39. 25	11	.894808	33. 58	.898230	33. 85
38. 92	.769632	39. 17	12	.896818	33. 50	.900256	33. 77
38. 83	.771975	39. 05	13	.898824	33. 43	.902278	33. 70
38. 72	.774312	38. 95	14	.900825	33 35	.904295	33. 62
38. 62	7.776643	38. 85	15	7.902821	33. 27	7.906307	33. 53
38. 52	.778968	38. 75	16	.904813	33. 20	.908315	33. 47
38. 42	.781286	38. 63	17	.906800	33. 12	.910319	33. 40
38. 30	.783599	38. 55	18	.908783	33. 05	.912317	33. 30
38. 22	.785905	38. 43	19	.910761	32. 97	.914312	33. 25
38. 10		38. 35			32. 90		33. 17
	7.788206		20	7.912735		7.916302	
38. 02	.790500	38. 23	21	.914704	32. 82	.918287	33. 08
37. 90	.792789	38. 15	22	.916668	32. 73	.920268	33. 02
37. 82	.795071	38. 03	23	.918629	32. 68	.922245	32. 95
37. 70	.797348	37. 95	24	.920584	32. 58	.924217	32. 87
37. 62	7.799619	37. 85	25	7.922536	32. 53	7.926184	32. 78
37. 52	.801884	37. 75	26	.924483	32. 45	.928148	32. 73
37. 40	.804143	37. 65	27	.926425	32. 37	.930107	32. 65
37. 33	.806397	37. 57	28	.928364	32. 32	.932062	32. 58
37. 22	.808644	37. 45	29	.930297	32. 22	.934012	32. 50
37. 13		37. 37			32. 17		32. 43
	7.810886		30	7.932227		7.935958	
37. 03	.813123	37. 28	31	.934152	32. 08	.937900	32. 37
36. 93	.815353	37. 17	32	.936073	32. 02	.939838	32. 30
36. 83	.817578	37. 08	33	.937990	31. 95	.941772	32. 23
36. 75	.819798	37. 00	34	.939903	31. 88	.943701	32. 15
36. 67	7.822012	36. 90	35	7.941811	31. 80	7.945626	32. 08
36. 55	.824220	36. 80	36	.943715	31. 73	.947547	32. 02
36. 48	.826423	36. 72	37	.945615	31. 67	.949464	31. 95
36. 37	.828620	36. 62	38	.947511	31. 60	.951376	31. 87
36. 28	.830812	36. 53	39	.949402	31. 52	.953285	31. 82
36. 20		36. 45			31. 47		31. 73
	7.832999		40	7.951290		7.955189	
36. 10	.835180	36. 35	41	.953173	31. 38	.957090	31. 68
36. 02	.837356	36. 27	42	.955052	31. 32	.958986	31. 60
35. 93	.839526	36. 17	43	.956928	31. 27	.960878	31. 53
35. 83	.841691	36. 08	44	.958799	31. 18	.962767	31. 48
35. 75	7.843851	36. 00	45	7.960666	31. 12	7.964651	31. 40
35. 65	.846005	35. 90	46	.962529	31. 05	.966531	31. 33
35. 58	.848155	35. 83	47	.964388	30. 98	.968408	31. 28
35. 48	.850299	35. 73	48	.966243	30. 92	.970280	31. 20
35. 40	.852437	35. 63	49	.968094	30. 85	.972148	31. 13
35. 30		35. 57			30. 78		31. 08
	7.854571		50	7.969941		7.974013	
35. 23	.856700	35. 48	51	.971785	30. 73	.975874	31. 02
35. 13	.858823	35. 38	52	.973624	30. 65	.977730	30. 93
35. 05	.860942	35. 32	53	.975459	30. 58	.979583	30. 88
34. 97	.863055	35. 22	54	.977291	30. 53	.981432	30. 82
34. 88	7.865163	35. 13	55	7.979118	30. 45	7.983277	30. 75
34. 80	.867266	35. 05	56	.980942	30. 40	.985119	30. 70
34. 72	.869365	34. 98	57	.982762	30. 33	.986956	30. 62
34. 63	.871458	34. 88	58	.984578	30. 27	.988790	30. 57
34. 55	.873546	34. 80	59	.986391	30.	.990620	30. 50
34. 47	7.875630	34. 73	60	7.988199			30. 43

12°					13°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec
0	8.339499	20.02	8.349095	20.47	0	8.408748	18.47	8.42002
1	.340700	20.00	.350323	20.43	1	.409856	18.43	.42116
2	.341900	19.95	.351549	20.42	2	.410962	18.42	.42229
3	.343097	19.95	.352774	20.38	3	.412067	18.40	.42343
4	.344294	19.90	.353997	20.35	4	.413171	18.38	.42456
5	8.345488	19.88	8.355218	20.33	5	8.414274	18.35	8.42569
6	.346681	19.85	.356438	20.30	6	.415375	18.32	.42682
7	.347872	19.82	.357656	20.28	7	.416474	18.30	.42795
8	.349061	19.80	.358873	20.25	8	.417572	18.28	.42908
9	.350249	19.77	.360088	20.22	9	.418669	18.25	.43020
10	8.351435	19.75	8.361301	20.20	10	8.419764	18.23	8.43133
11	.352620	19.72	.362513	20.18	11	.420858	18.22	.43245
12	.353803	19.68	.363724	20.13	12	.421951	18.18	.43358
13	.354984	19.67	.364932	20.12	13	.423042	18.17	.43470
14	.356164	19.63	.366139	20.10	14	.424132	18.13	.43582
15	8.357342	19.60	8.367345	20.07	15	8.425220	18.12	8.43693
16	.358518	19.58	.368549	20.03	16	.426307	18.10	.43805
17	.359693	19.55	.369751	20.02	17	.427393	18.07	.43917
18	.360866	19.53	.370952	19.98	18	.428477	18.05	.44028
19	.362038	19.50	.372151	19.95	19	.429560	18.02	.44139
20	8.363208	19.48	8.373348	19.95	20	8.430641	18.02	8.44250
21	.364377	19.43	.374545	19.90	21	.431722	17.97	.44361
22	.365543	19.43	.375739	19.88	22	.432800	17.97	.44472
23	.366709	19.38	.376932	19.85	23	.433878	17.93	.44583
24	.367872	19.37	.378123	19.83	24	.434954	17.92	.44694
25	8.369034	19.35	8.379313	19.82	25	8.436029	17.88	8.44804
26	.370195	19.32	.380502	19.78	26	.437102	17.87	.44914
27	.371354	19.28	.381689	19.75	27	.438174	17.85	.45025
28	.372511	19.27	.382874	19.73	28	.439245	17.82	.45135
29	.373667	19.25	.384058	19.70	29	.440314	17.80	.45245
30	8.374822	19.20	8.385240	19.68	30	8.441382	17.78	8.45355
31	.375974	19.18	.386421	19.65	31	.442449	17.75	.45464
32	.377125	19.17	.387600	19.63	32	.443514	17.73	.45574
33	.378275	19.13	.388778	19.60	33	.444578	17.72	.45683
34	.379423	19.12	.389954	19.58	34	.445641	17.68	.45793
35	8.380570	19.08	8.391129	19.55	35	8.446702	17.68	8.45902
36	.381715	19.05	.392302	19.53	36	.447763	17.63	.46011
37	.382858	19.03	.393474	19.50	37	.448821	17.63	.46120
38	.384000	19.02	.394644	19.48	38	.449879	17.60	.46229
39	.385141	18.98	.395813	19.45	39	.450935	17.58	.46337
40	8.386280	18.95	8.396980	19.43	40	8.451990	17.55	8.46446
41	.387417	18.93	.398146	19.42	41	.453043	17.55	.46554
42	.388553	18.92	.399311	19.38	42	.454096	17.52	.46663
43	.389688	18.88	.400474	19.35	43	.455147	17.48	.46771
44	.390821	18.85	.401635	19.33	44	.456196	17.48	.46879
45	8.391952	18.83	8.402795	19.32	45	8.457245	17.45	8.46987
46	.393082	18.82	.403954	19.28	46	.458292	17.43	.47095
47	.394211	18.78	.405111	19.27	47	.459338	17.40	.47202
48	.395338	18.75	.406267	19.23	48	.460382	17.40	.47310
49	.396463	18.73	.407421	19.22	49	.461426	17.37	.47417
50	8.397587	18.72	8.408574	19.18	50	8.462468	17.35	8.47525
51	.398710	18.68	.409725	19.17	51	.463509	17.32	.47632
52	.399831	18.67	.410875	19.13	52	.464548	17.30	.47739
53	.400951	18.63	.412023	19.13	53	.465586	17.28	.47846
54	.402069	18.62	.413171	19.08	54	.466623	17.27	.47953
55	8.403186	18.58	8.414316	19.08	55	8.467659	17.23	8.48059
56	.404301	18.57	.415461	19.03	56	.468693	17.23	.48166
57	.405415	18.53	.416603	19.03	57	.469727	17.20	.48272
58	.406527	18.52	.417745	19.00	58	.470759	17.17	.48379
59	.407638	18.50	.418885	18.98	59	.471789	17.17	.48485
60	8.408748		8.420024		60	8.472819		8.48591

	14°				15°				
	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
0	8.472819	17.13	8.485915	17.67	0	8.532425	15.98	8.547482	16.53
1	.473847	17.12	.486975	17.63	1	.533384	15.97	.548474	16.53
2	.474874	17.10	.488033	17.63	2	.534342	15.95	.549466	16.52
3	.475900	17.08	.489091	17.60	3	.535299	15.93	.550457	16.50
4	.476925	17.05	.490147	17.58	4	.536255	15.92	.551447	16.48
5	8.477948	17.03	8.491202	17.57	5	8.537210	15.88	8.552436	16.47
6	.478970	17.02	.492256	17.53	6	.538163	15.88	.553424	16.43
7	.479991	17.00	.493308	17.53	7	.539116	15.87	.554410	16.43
8	.481011	16.97	.494360	17.50	8	.540068	15.83	.555396	16.42
9	.482029	16.95	.495410	17.48	9	.541018	15.83	.556381	16.38
10	8.483046	16.93	8.496459	17.47	10	8.541968	15.80	8.557364	16.38
11	.484062	16.92	.497507	17.45	11	.542916	15.78	.558347	16.37
12	.485077	16.90	.498554	17.43	12	.543863	15.78	.559329	16.33
13	.486091	16.87	.499600	17.40	13	.544810	15.75	.560309	16.33
14	.487103	16.87	.500644	17.38	14	.545755	15.73	.561289	16.30
15	8.488115	16.83	8.501687	17.38	15	8.546699	15.72	8.562267	16.30
16	.489125	16.82	.502730	17.35	16	.547642	15.70	.563245	16.28
17	.490134	16.78	.503771	17.32	17	.548584	15.68	.564222	16.25
18	.491141	16.78	.504810	17.32	18	.549525	15.67	.565197	16.25
19	.492148	16.75	.505849	17.30	19	.550465	15.65	.566172	16.22
20	8.493153	16.73	8.506887	17.27	20	8.551404	15.63	8.567145	16.22
21	.494157	16.72	.507923	17.25	21	.552342	15.62	.568118	16.20
22	.495160	16.70	.508958	17.25	22	.553279	15.60	.569090	16.17
23	.496162	16.67	.509993	17.22	23	.554215	15.58	.570060	16.17
24	.497162	16.67	.511026	17.18	24	.555150	15.57	.571030	16.15
25	8.498162	16.63	8.512057	17.18	25	8.556084	15.55	8.571999	16.12
26	.499160	16.62	.513088	17.17	26	.557017	15.53	.572966	16.12
27	.500157	16.60	.514118	17.13	27	.557949	15.50	.573933	16.10
28	.501153	16.58	.515146	17.13	28	.558879	15.50	.574899	16.08
29	.502148	16.57	.516174	17.10	29	.559809	15.48	.575864	16.05
30	8.503142	16.53	8.517200	17.08	30	8.560738	15.47	8.576827	16.05
31	.504134	16.52	.518225	17.07	31	.561666	15.43	.577790	16.03
32	.505125	16.52	.519249	17.05	32	.562592	15.43	.578752	16.02
33	.506116	16.48	.520272	17.03	33	.563518	15.42	.579713	16.00
34	.507105	16.45	.521294	17.02	34	.564443	15.40	.580673	15.98
35	8.508092	16.45	8.522315	16.98	35	8.565367	15.37	8.581632	15.97
36	.509079	16.43	.523334	16.98	36	.566289	15.37	.582590	15.95
37	.510065	16.40	.524353	16.95	37	.567211	15.35	.583547	15.93
38	.511049	16.40	.525370	16.95	38	.568132	15.33	.584503	15.92
39	.512033	16.37	.526387	16.92	39	.569052	15.30	.585458	15.90
40	8.513015	16.35	8.527402	16.90	40	8.569970	15.30	8.586412	15.88
41	.513996	16.33	.528416	16.88	41	.570888	15.28	.587365	15.88
42	.514976	16.32	.529429	16.87	42	.571805	15.27	.588318	15.85
43	.515955	16.28	.530441	16.85	43	.572721	15.25	.589269	15.83
44	.516932	16.28	.531452	16.83	44	.573636	15.22	.590219	15.83
45	8.517909	16.25	8.532462	16.82	45	8.574549	15.22	8.591169	15.80
46	.518884	16.25	.533471	16.78	46	.575462	15.20	.592117	15.80
47	.519859	16.22	.534478	16.78	47	.576374	15.18	.593065	15.78
48	.520832	16.20	.535485	16.75	48	.577285	15.17	.594012	15.75
49	.521804	16.18	.536490	16.75	49	.578195	15.15	.594957	15.75
50	8.522775	16.17	8.537495	16.72	50	8.579104	15.13	8.595902	15.73
51	.523745	16.15	.538498	16.72	51	.580012	15.12	.596846	15.72
52	.524714	16.13	.539501	16.68	52	.580919	15.10	.597789	15.70
53	.525682	16.10	.540502	16.67	53	.581825	15.08	.598731	15.68
54	.526648	16.10	.541502	16.65	54	.582730	15.07	.599672	15.67
55	8.527614	16.07	8.542501	16.63	55	8.583634	15.05	8.600612	15.65
56	.528578	16.07	.543499	16.63	56	.584537	15.05	.601551	15.65
57	.529542	16.03	.544497	16.60	57	.585440	15.02	.602490	15.62
58	.530504	16.02	.545493	16.58	58	.586341	15.00	.603427	15.60
59	.531465	16.00	.546488	16.57	59	.587241	15.00	.604363	15.60
60	8.532425		8.547482		60	8.588141		8.605299	

16°					17°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exse
0	8.588141	14.97	8.605299	15.58	0	8.640434	14.08	8.659
1	.589039	14.95	.606234	15.55	1	.641279	14.07	.660
2	.589936	14.95	.607167	15.55	2	.642123	14.07	.661
3	.590833	14.95	.608100	15.53	3	.642966	14.05	.662
4	.591729	14.93	.609032	15.52	4	.643809	14.05	.663
5	8.592623	14.90	8.609963	15.50	5	8.644650	14.02	8.664
6	.593517	14.90	.610893	15.50	6	.645491	14.02	.665
7	.594410	14.88	.611823	15.50	7	.646331	14.00	.666
8	.595302	14.87	.612751	15.47	8	.647170	13.98	.666
9	.596192	14.83	.613678	15.45	9	.648008	13.97	.667
10	8.597082	14.83	8.614605	15.45	10	8.648845	13.95	8.668
11	.597971	14.82	.615531	15.43	11	.649682	13.95	.669
12	.598860	14.82	.616456	15.42	12	.650518	13.93	.670
13	.599747	14.78	.617379	15.38	13	.651353	13.92	.671
14	.600633	14.77	.618302	15.38	14	.652187	13.90	.672
15	8.601518	14.75	8.619225	15.38	15	8.653020	13.88	8.673
16	.602403	14.75	.620146	15.35	16	.653852	13.87	.673
17	.603286	14.72	.621066	15.33	17	.654684	13.87	.674
18	.604169	14.72	.621986	15.33	18	.655515	13.85	.675
19	.605051	14.70	.622904	15.30	19	.656345	13.83	.676
20	8.605931	14.67	8.623822	15.30	20	8.657174	13.82	8.677
21	.606811	14.67	.624739	15.28	21	.658003	13.82	.678
22	.607690	14.65	.625655	15.27	22	.658830	13.78	.679
23	.608568	14.63	.626570	15.25	23	.659657	13.78	.679
24	.609445	14.62	.627484	15.23	24	.660483	13.77	.680
25	8.610321	14.60	8.628398	15.23	25	8.661308	13.75	8.681
26	.611197	14.60	.629310	15.20	26	.662132	13.73	.682
27	.612071	14.57	.630222	15.20	27	.662956	13.73	.683
28	.612945	14.57	.631133	15.18	28	.663779	13.72	.684
29	.613817	14.53	.632043	15.17	29	.664601	13.70	.685
30	8.614689	14.53	8.632952	15.15	30	8.665422	13.68	8.686
31	.615560	14.52	.633860	15.13	31	.666242	13.67	.686
32	.616430	14.50	.634768	15.13	32	.667062	13.67	.687
33	.617299	14.48	.635674	15.10	33	.667881	13.65	.688
34	.618167	14.47	.636580	15.10	34	.668699	13.63	.689
35	8.619034	14.45	8.637485	15.08	35	8.669516	13.62	8.690
36	.619901	14.45	.638389	15.07	36	.670332	13.60	.691
37	.620766	14.42	.639292	15.05	37	.671148	13.60	.692
38	.621631	14.42	.640195	15.05	38	.671963	13.58	.692
39	.622495	14.40	.641096	15.02	39	.672777	13.57	.693
40	8.623358	14.38	8.641997	15.02	40	8.673590	13.55	8.694
41	.624220	14.37	.642897	15.00	41	.674403	13.55	.695
42	.625081	14.35	.643796	14.98	42	.675215	13.53	.696
43	.625941	14.33	.644694	14.97	43	.676026	13.52	.697
44	.626801	14.33	.645591	14.95	44	.676836	13.50	.697
45	8.627659	14.30	8.646488	14.95	45	8.677645	13.48	8.698
46	.628517	14.30	.647384	14.93	46	.678454	13.48	.699
47	.629374	14.28	.648279	14.92	47	.679262	13.47	.700
48	.630230	14.27	.649173	14.90	48	.680069	13.45	.701
49	.631085	14.25	.650066	14.88	49	.680875	13.43	.702
50	8.631939	14.23	8.650958	14.87	50	8.681681	13.43	8.703
51	.632792	14.22	.651850	14.87	51	.682486	13.42	.703
52	.633645	14.22	.652741	14.85	52	.683290	13.40	.704
53	.634496	14.18	.653631	14.83	53	.684093	13.38	.705
54	.635347	14.18	.654520	14.82	54	.684896	13.38	.706
55	8.636197	14.17	8.655408	14.80	55	8.685697	13.35	8.707
56	.637046	14.15	.656296	14.80	56	.686498	13.35	.708
57	.637894	14.13	.657182	14.77	57	.687299	13.35	.708
58	.638742	14.13	.658068	14.77	58	.688098	13.32	.709
59	.639588	14.10	.658954	14.77	59	.688897	13.32	.710
60	8.640434	14.10	8.659838	14.73	60	8.689695	13.30	8.711

M.	18° Vers.	D. 1″.	Exsec.	D. 1″.	M.	19° Vers.	D. 1″.	Exsec.	D. 1″.
0	8.689695	13.28	8.711489	13.97	0	8.736248	12.58	8.760578	13.30
1	.690492	13.28	.712327	13.95	1	.737003	12.57	.761376	13.30
2	.691289	13.25	.713164	13.95	2	.737757	12.55	.762174	13.28
3	.692084	13.25	.714001	13.95	3	.738510	12.55	.762971	13.27
4	.692879	13.25	.714838	13.92	4	.739263	12.53	.763767	13.27
5	8.693674	13.22	8.715673	13.92	5	8.740015	12.52	8.764563	13.25
6	.694467	13.22	.716508	13.90	6	.740766	12.50	.765358	13.23
7	.695260	13.20	.717342	13.88	7	.741516	12.50	.766152	13.23
8	.696052	13.18	.718175	13.88	8	.742266	12.50	.766946	13.23
9	.696843	13.18	.719008	13.87	9	.743016	12.47	.767739	13.20
10	8.697634	13.17	8.719840	13.85	10	8.743764	12.47	8.768531	13.20
11	.698424	13.15	.720671	13.85	11	.744512	12.45	.769323	13.18
12	.699213	13.13	.721502	13.83	12	.745259	12.45	.770114	13.18
13	.700001	13.13	.722332	13.82	13	.746006	12.43	.770905	13.17
14	.700789	13.12	.723161	13.80	14	.746752	12.42	.771695	13.15
15	8.701576	13.10	8.723989	13.80	15	8.747497	12.42	8.772484	13.15
16	.702362	13.08	.724817	13.78	16	.748242	12.40	.773273	13.13
17	.703147	13.08	.725644	13.78	17	.748986	12.38	.774061	13.13
18	.703932	13.07	.726471	13.77	18	.749729	12.38	.774849	13.10
19	.704716	13.05	.727297	13.75	19	.750472	12.37	.775635	13.12
20	8.705499	13.05	8.728122	13.73	20	8.751214	12.35	8.776422	13.08
21	.706282	13.02	.728946	13.73	21	.751955	12.35	.777207	13.10
22	.707063	13.02	.729770	13.72	22	.752696	12.33	.777993	13.07
23	.707844	13.02	.730593	13.70	23	.753436	12.32	.778777	13.07
24	.708625	12.98	.731415	13.70	24	.754175	12.32	.779561	13.05
25	8.709404	12.98	8.732237	13.68	25	8.754914	12.30	8.780344	13.05
26	.710183	12.97	.733058	13.67	26	.755652	12.28	.781127	13.03
27	.710961	12.97	.733878	13.67	27	.756389	12.28	.781909	13.02
28	.711739	12.95	.734698	13.65	28	.757126	12.27	.782690	13.02
29	.712516	12.93	.735517	13.63	29	.757862	12.27	.783471	13.00
30	8.713292	12.92	8.736335	13.63	30	8.758598	12.25	8.784251	13.00
31	.714067	12.92	.737153	13.62	31	.759333	12.23	.785031	12.98
32	.714842	12.90	.737970	13.60	32	.760067	12.23	.785810	12.97
33	.715616	12.88	.738786	13.60	33	.760801	12.22	.786588	12.97
34	.716389	12.87	.739602	13.58	34	.761534	12.20	.787366	12.97
35	8.717161	12.87	8.740417	13.57	35	8.762266	12.20	8.788144	12.93
36	.717933	12.85	.741231	13.57	36	.762998	12.18	.788920	12.93	
37	.718704	12.85	.742045	13.55	37	.763729	12.17	.789696	12.93
38	.719475	12.82	.742858	13.53	38	.764459	12.17	.790472	12.92
39	.720244	12.82	.743670	13.53	39	.765189	12.15	.791247	12.90
40	8.721013	12.82	8.744482	13.52	40	8.765918	12.15	8.792021	12.90
41	.721782	12.78	.745293	13.50	41	.766647	12.12	.792795	12.88
42	.722549	12.78	.746103	13.50	42	.767374	12.13	.793568	12.87
43	.723316	12.78	.746913	13.48	43	.768102	12.10	.794340	12.87
44	.724083	12.75	.747722	13.47	44	.768828	12.10	.795112	12.87
45	8.724848	12.75	8.748530	13.47	45	8.769554	12.10	8.795884	12.83
46	.725613	12.73	.749338	13.45	46	.770280	12.08	.796654	12.85
47	.726377	12.72	.750145	13.43	47	.771005	12.07	.797425	12.82
48	.727140	12.72	.750951	13.43	48	.771729	12.05	.798194	12.82
49	.727903	12.70	.751757	13.42	49	.772452	12.05	.798963	12.82
50	8.728665	12.70	8.752562	13.42	50	8.773175	12.05	8.799732	12.80
51	.729427	12.67	.753367	13.40	51	.773898	12.02	.800500	12.78
52	.730187	12.67	.754171	13.38	52	.774619	12.02	.801267	12.78
53	.730947	12.67	.754974	13.37	53	.775340	12.02	.802034	12.77
54	.731707	12.63	.755776	13.37	54	.776061	12.00	.802800	12.75
55	8.732465	12.63	8.756578	13.37	55	8.776781	11.98	8.803565	12.75
56	.733223	12.63	.757380	13.33	56	.777500	11.97	.804330	12.75
57	.733981	12.60	.758180	13.33	57	.778218	11.97	.805095	12.73
58	.734737	12.60	.758980	13.33	58	.778936	11.97	.805859	12.72
59	.735493	12.58	.759780	13.30	59	.779654	11.93	.806622	12.72
60	8.736248		8.760578		60	8.780370		8.807385	

24°					25°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
0	8.936788	9.90	8.976058	10.83	0	8.971703	9.50	9.014428	10.47
1	.937382	9.90	.976708	10.83	1	.972273	9.48	.015056	10.45
2	.937976	9.88	.977358	10.83	2	.972842	9.48	.015685	10.45
3	.938569	9.88	.978008	10.82	3	.973411	9.48	.016312	10.47
4	.939162	9.87	.978657	10.82	4	.973980	9.47	.016940	10.45
5	8.939754	9.87	8.979306	10.80	5	8.974548	9.47	9.017567	10.43
6	.940346	9.87	.979954	10.80	6	.975116	9.45	.018194	10.45
7	.940938	9.85	.980602	10.80	7	.975683	9.45	.018821	10.43
8	.941529	9.85	.981250	10.80	8	.976250	9.43	.019447	10.43
9	.942120	9.83	.981898	10.78	9	.976816	9.43	.020073	10.42
10	8.942710	9.83	8.982545	10.77	10	8.977382	9.43	9.020698	10.42
11	.943300	9.82	.983191	10.77	11	.977948	9.43	.021323	10.42
12	.943889	9.83	.983837	10.77	12	.978514	9.40	.021948	10.40
13	.944479	9.80	.984483	10.77	13	.979078	9.42	.022572	10.42
14	.945067	9.80	.985129	10.75	14	.979643	9.40	.023197	10.38
15	8.945655	9.80	8.985774	10.75	15	8.980207	9.40	9.023820	10.40
16	.946243	9.80	.986419	10.73	16	.980771	9.40	.024444	10.38
17	.946831	9.78	.987063	10.73	17	.981335	9.38	.025067	10.38
18	.947418	9.77	.987707	10.73	18	.981898	9.37	.025690	10.37
19	.948004	9.77	.988351	10.72	19	.982460	9.38	.026312	10.37
20	8.948590	9.77	8.988994	10.72	20	8.983023	9.37	9.026934	10.37
21	.949176	9.75	.989637	10.70	21	.983585	9.35	.027556	10.35
22	.949761	9.75	.990279	10.72	22	.984146	9.35	.028177	10.35
23	.950346	9.75	.990922	10.68	23	.984707	9.35	.028798	10.33
24	.950931	9.73	.991563	10.70	24	.985268	9.33	.029419	10.33
25	8.951515	9.73	8.992205	10.68	25	8.985828	9.33	9.030039	10.33
26	.952099	9.72	.992846	10.68	26	.986388	9.33	.030659	10.33
27	.952682	9.72	.993487	10.67	27	.986948	9.32	.031279	10.33
28	.953265	9.70	.994127	10.67	28	.987507	9.32	.031899	10.32
29	.953847	9.70	.994767	10.65	29	.988066	9.32	.032518	10.30
30	8.954429	9.70	8.995406	10.67	30	8.988625	9.30	9.033136	10.32
31	.955011	9.68	.996046	10.65	31	.989183	9.28	.033755	10.30
32	.955592	9.68	.996685	10.63	32	.989740	9.30	.034373	10.28
33	.956173	9.67	.997323	10.63	33	.990298	9.28	.034991	10.28
34	.956753	9.68	.997961	10.63	34	.990855	9.27	.035608	10.28
35	8.957334	9.65	8.998599	10.62	35	8.991411	9.28	9.036225	10.28
36	.957913	9.65	.999236	10.62	36	.991968	9.25	.036842	10.27
37	.958492	9.65	.999873	10.62	37	.992523	9.27	.037458	10.27
38	.959071	9.65	9.000510	10.62	38	.993079	9.25	.038074	10.27
39	.959650	9.62	.001147	10.60	39	.993634	9.25	.038690	10.25
40	8.960227	9.63	9.001783	10.58	40	8.994189	9.23	9.039305	10.25
41	.960805	9.62	.002418	10.58	41	.994743	9.23	.039920	10.25
42	.961382	9.62	.003053	10.58	42	.995297	9.23	.040535	10.25
43	.961959	9.60	.003688	10.58	43	.995851	9.22	.041150	10.23
44	.962535	9.60	.004323	10.57	44	.996404	9.22	.041764	10.23
45	8.963111	9.60	9.004957	10.57	45	8.996957	9.20	9.042378	10.22
46	.963687	9.58	.005591	10.55	46	.997509	9.22	.042991	10.23
47	.964262	9.58	.006224	10.57	47	.998062	9.18	.043604	10.22
48	.964837	9.57	.006858	10.53	48	.998613	9.20	.044217	10.22
49	.965411	9.57	.007490	10.55	49	.999165	9.18	.044830	10.20
50	8.965985	9.57	9.008123	10.53	50	8.999716	9.17	9.045442	10.20
51	.966559	9.55	.008755	10.53	51	9.000266	9.18	.046054	10.18
52	.967132	9.55	.009387	10.52	52	.000817	9.17	.046665	10.18
53	.967705	9.53	.010018	10.52	53	.001367	9.15	.047276	10.18
54	.968277	9.53	.010649	10.52	54	.001916	9.17	.047887	10.18
55	8.968849	9.53	9.011280	10.50	55	9.002466	9.13	9.048498	10.17
56	.969421	9.52	.011910	10.50	56	.003014	9.15	.049108	10.17
57	.969992	9.52	.012540	10.50	57	.003563	9.13	.049718	10.17
58	.970563	9.50	.013170	10.48	58	.004111	9.13	.050328	10.13
59	.971133	9.50	.013799	10.48	59	.004659	9.12	.050937	10.13
60	8.971703		9.014428		60	9.005206		9.051546	

26°				27°				
rs.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
5206	9. 12	9. 051546	10. 15	0	9. 037401	8. 77	9. 087520	9. 83
5753	9. 12	.052155	10. 13	1	.037927	8. 75	.088110	9. 83
6300	9. 10	.052763	10. 13	2	.038452	8. 77	.088700	9. 83
6846	9. 10	.053371	10. 13	3	.038978	8. 75	.089290	9. 83
7392	9. 10	.053979	10. 12	4	.039503	8. 73	.089880	9. 82
7938	9. 08	9. 054586	10. 12	5	9. 040027	8. 75	9. 090469	9. 82
8483	9. 08	.055193	10. 12	6	.040552	8. 73	.091058	9. 82
9028	9. 07	.055800	10. 10	7	.041076	8. 72	.091647	9. 80
9572	9. 07	.056406	10. 10	8	.041599	8. 73	.092235	9. 80
0116	9. 07	.057012	10. 10	9	.042123	8. 72	.092823	9. 80
0660	9. 05	9. 057618	10. 10	10	9. 042646	8. 70	9. 093411	9. 78
1203	9. 05	.058224	10. 08	11	.043168	8. 72	.093998	9. 80
1746	9. 05	.058829	10. 08	12	.043691	8. 70	.094586	9. 78
2289	9. 03	.059434	10. 07	13	.044213	8. 70	.095173	9. 77
2831	9. 03	.060038	10. 08	14	.044735	8. 68	.095759	9. 78
3373	9. 03	9. 060643	10. 07	15	9. 045256	8. 68	9. 096346	9. 77
3915	9. 02	.061247	10. 05	16	.045777	8. 68	.096932	9. 77
4456	9. 02	.061850	10. 07	17	.046298	8. 67	.097518	9. 75
4997	9. 02	.062454	10. 05	18	.046818	8. 67	.098103	9. 77
5538	9. 00	.063057	10. 03	19	.047338	8. 67	.098689	9. 75
6078	9. 00	9. 063659	10. 05	20	9. 047858	8. 65	9. 099274	9. 73
6618	8. 98	.064262	10. 03	21	.048377	8. 65	.099858	9. 75
7157	9. 00	.064864	10. 03	22	.048896	8. 65	.100443	9. 73
7697	8. 97	.065466	10. 02	23	.049415	8. 63	.101027	9. 73
8235	8. 98	.066067	10. 02	24	.049933	8. 63	.101611	9. 72
8774	8. 97	9. 066668	10. 02	25	9. 050451	8. 63	9. 102194	9. 73
9312	8. 97	.067269	10. 02	26	.050969	8. 63	.102778	9. 72
9850	8. 95	.067870	10. 00	27	.051487	8. 62	.103361	9. 70
0387	8. 95	.068470	10. 00	28	.052004	8. 60	.103943	9. 72
0924	8. 95	.069070	10. 00	29	.052520	8. 62	.104526	9. 70
1461	8. 93	9. 069670	9. 98	30	9. 053037	8. 60	9. 105108	9. 70
1997	8. 93	.070269	9. 98	31	.053553	8. 60	.105690	9. 68
2533	8. 93	.070868	9. 98	32	.054069	8. 58	.106271	9. 70
3069	8. 92	.071467	9. 97	33	.054584	8. 58	.106853	9. 68
3604	8. 92	.072065	9. 97	34	.055099	8. 58	.107434	9. 68
4139	8. 90	9. 072663	9. 97	35	9. 055614	8. 58	9. 108015	9. 67
4673	8. 92	.073261	9. 97	36	.056129	8. 57	.108595	9. 67
5208	8. 90	.073859	9. 95	37	.056643	8. 57	.109175	9. 67
5742	8. 88	.074456	9. 95	38	.057157	8. 55	.109755	9. 67
6275	8. 88	.075053	9. 93	39	.057670	8. 55	.110335	9. 65
6808	8. 88	9. 075649	9. 95	40	9. 058183	8. 55	9. 110914	9. 67
7341	8. 88	.076246	9. 93	41	.058696	8. 55	.111494	9. 63
7874	8. 87	.076842	9. 92	42	.059209	8. 53	.112072	9. 65
8406	8. 87	.077437	9. 93	43	.059721	8. 53	.112651	9. 63
8938	8. 85	.078033	9. 92	44	.060233	8. 53	.113229	9. 63
9469	8. 85	9. 078628	9. 92	45	9. 060745	8. 52	9. 113807	9. 63
0000	8. 85	.079223	9. 90	46	.061256	8. 52	.114385	9. 63
0531	8. 85	.079817	9. 92	47	.061767	8. 50	.114963	9. 62
1062	8. 83	.080412	9. 90	48	.062277	8. 52	.115540	9. 62
1592	8. 83	.081006	9. 88	49	.062788	8. 50	.116117	9. 60
2122	8. 82	9. 081599	9. 90	50	9. 063298	8. 48	9. 116693	9. 62
2651	8. 82	.082193	9. 88	51	.063807	8. 50	.117270	9. 60
3180	8. 82	.082786	9. 87	52	.064317	8. 48	.117846	9. 60
3709	8. 80	.083378	9. 88	53	.064826	8. 48	.118422	9. 58
4237	8. 80	.083971	9. 87	54	.065335	8. 47	.118997	9. 60
4765	8. 80	9. 084563	9. 87	55	9. 065843	8. 47	9. 119573	9. 58
5293	8. 78	.085155	9. 87	56	.066351	8. 47	.120148	9. 58
5820	8. 78	.085747	9. 85	57	.066859	8. 45	.120723	9. 57
6347	8. 78	.086338	9. 85	58	.067366	8. 47	.121297	9. 57
6874	8. 78	.086929	9. 85	59	.067874	8. 43	.121871	9. 57
7401		9. 087520		60	9. 068380		9. 122445	

28°					29°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exs
0	9.068380	8.45	9.122445	9.57	0	9.098229	8.15	9.1
1	.068887	8.43	.123019	9.57	1	.098718	8.13	.1
2	.069393	8.43	.123593	9.55	2	.099206	8.12	.1
3	.069899	8.43	.124166	9.55	3	.099693	8.13	.1
4	.070405	8.42	.124739	9 53	4	.100181	8.12	.1
5	9.070910	8.42	9.125311	9.55	5	9.100668	8.12	9.1
6	.071415	8.40	.125884	9.53	6	.101155	8.12	.1
7	.071919	8.42	.126456	9.53	7	.101642	8.10	.1
8	.072424	8.40	.127028	9.52	8	.102128	8.10	.1
9	.072928	8.40	.127599	9.53	9	.102614	8.10	.1
10	9.073432	8.38	9.128171	9.52	10	9.103100	8.08	9.1
11	.073935	8.38	.128742	9.52	11	.103585	8.08	.1
12	.074438	8.38	.129313	9.50	12	.104070	8.08	.1
13	.074941	8.37	.129883	9.50	13	.104555	8.08	.1
14	.075443	8.38	.130453	9.50	14	.105040	8.07	.1
15	9.075946	8.35	9.131023	9.50	15	9.105524	8.07	9.1
16	.076447	8.37	.131593	9.50	16	.106008	8.05	.1
17	.076949	8.35	.132163	9.48	17	.106491	8.07	.1
18	.077450	8.35	.132732	9.48	18	.106975	8.05	.1
19	.077951	8.35	.133301	9.48	19	.107458	8.05	.1
20	9.078452	8.33	9.133870	9.47	20	9.107941	8.03	9.1
21	.078952	8.33	.134438	9.47	21	.108423	8.05	.1
22	.079452	8.33	.135006	9.47	22	.108906	8.03	.1
23	.079952	8.32	.135574	9.47	23	.109388	8.02	.1
24	.080451	8.32	.136142	9.45	24	.109869	8.03	.1
25	9.080950	8.32	9.136709	9.47	25	9.110351	8.02	9.1
26	.081449	8.32	.137277	9.45	26	.110832	8.02	.1
27	.081948	8.30	.137844	9.43	27	.111313	8.00	.1
28	.082446	8.30	.138410	9.45	28	.111793	8.00	.1
29	.082944	8.28	.138977	9.43	29	.112273	8.00	.1
30	9.083441	8.30	9.139543	9.43	30	9.112753	8.00	9.1
31	.083939	8.28	.140109	9.42	31	.113233	8.00	.1
32	.084436	8.27	.140674	9.43	32	.113713	7.98	.1
33	.084932	8.28	.141240	9.42	33	.114192	7.98	.1
34	.085429	8.27	.141805	9.42	34	.114671	7.97	.1
35	9.085925	8.25	9.142370	9.40	35	9.115149	7.97	9.1
36	.086420	8.27	.142934	9.42	36	.115627	7.97	.1
37	.086916	8.25	.143499	9.40	37	.116105	7.97	.1
38	.087411	8.25	.144063	9.40	38	.116583	7.97	.1
39	.087906	8.23	.144627	9.38	39	.117061	7.95	.1
40	9.088400	8.25	9.145190	9.40	40	9.117538	7.95	9.1
41	.088895	8.23	.145754	9.38	41	.118015	7.93	.1
42	.089389	8.22	.146317	9.38	42	.118491	7.95	.1
43	.089882	8.23	.146880	9.37	43	.118968	7.93	.1
44	.090376	8.22	.147442	9.38	44	.119444	7.92	.1
45	9.090869	8.22	9.148005	9.37	45	9.119919	7.93	9.1
46	.091362	8.20	.148567	9.37	46	.120395	7.92	.1
47	.091854	8.20	.149129	9.35	47	.120870	7.92	.1
48	.092346	8.20	.149690	9.35	48	.121345	7.92	.1
49	.092838	8.20	.150251	9.37	49	.121820	7.90	.1
50	9.093330	8.18	9.150813	9.33	50	9.122294	7.90	9.1
51	.093821	8.18	.151373	9.35	51	.122768	7.90	.1
52	.094312	8.18	.151934	9.33	52	.123242	7.88	.1
53	.094803	8.17	.152494	9.35	53	.123715	7.90	.1
54	.095293	8.17	.153055	9.32	54	.124189	7.88	.1
55	9.095783	8.17	9.153614	9.33	55	9.124662	7.87	9.1
56	.096273	8.17	.154174	9.32	56	.125134	7.88	.1
57	.096763	8.15	.154733	9.33	57	.125607	7.87	.1
58	.097252	8.15	.155293	9.30	58	.126079	7.87	.1
59	.097741	8.13	.155851	9.32	59	.126551	7.85	.1
60	9.098229		9.156410		60	9.127022		9.1

	30°				31°			
's.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
022	7.87	9.189492	9.07	0	9.154828	7.58	9.221762	8.85
494	7.85	.190036	9.07	1	.155283	7.58	.222293	8.87
965	7.85	.190580	9.07	2	.155738	7.58	.222825	8.83
436	7.85	.191124	9.07	3	.156193	7.58	.223355	8.85
906	7.83	.191668	9.05	4	.156648	7.57	.223886	8.85
376	7.83	9.192211	9.05	5	9.157102	7.57	9.224417	8.83
846	7.83	.192754	9.05	6	.157556	7.57	.224947	8.83
316	7.83	.193297	9.05	7	.158010	7.57	.225477	8.83
785	7.82	.193840	9.03	8	.158464	7.55	.226007	8.83
255	7.83	.194382	9.05	9	.158917	7.55	.226537	8.82
724	7.80	9.194925	9.03	10	9.159370	7.55	9.227066	8.82
192	7.80	.195467	9.03	11	.159823	7.55	.227595	8.83
660	7.82	.196009	9.02	12	.160276	7.53	.228125	8.80
129	7.78	.196550	9.03	13	.160728	7.53	.228653	8.82
596	7.80	.197092	9.02	14	.161180	7.53	.229182	8.82
064	7.78	9.197633	9.02	15	9.161632	7.52	9.229711	8.80
531	7.78	.198174	9.02	16	.162083	7.53	.230239	8.80
998	7.78	.198715	9.00	17	.162535	7.52	.230767	8.80
465	7.77	.199255	9.00	18	.162986	7.52	.231295	8.78
931	7.77	.199795	9.00	19	.163437	7.50	.231822	8.80
397	7.77	9.200335	9.00	20	9.163887	7.52	9.232350	8.78
863	7.77	.200875	9.00	21	.164338	7.50	.232877	8.78
329	7.75	.201415	8.98	22	.164788	7.48	.233404	8.78
794	7.77	.201954	9.00	23	.165237	7.50	.233931	8.78
260	7.73	.202494	8.98	24	.165687	7.48	.234458	8.77
724	7.75	9.203033	8.97	25	9.166136	7.48	9.234984	8.77
189	7.73	.203571	8.98	26	.166585	7.48	.235510	8.77
653	7.73	.204110	8.97	27	.167034	7.48	.236036	8.77
117	7.73	.204648	8.97	28	.167483	7.47	.236562	8.77
581	7.73	.205186	8.97	29	.167931	7.47	.237088	8.75
045	7.72	9.205724	8.97	30	9.168379	7.47	9.237613	8.77
508	7.72	.206262	8.95	31	.168827	7.47	.238139	8.75
971	7.72	.206799	8.97	32	.169275	7.45	.238664	8.75
434	7.70	.207337	8.95	33	.169722	7.45	.239189	8.73
896	7.70	.207874	8.93	34	.170169	7.45	.239713	8.75
358	7.70	9.208410	8.95	35	9.170616	7.43	9.240238	8.73
820	7.70	.208947	8.93	36	.171062	7.45	.240762	8.73
282	7.68	.209483	8.95	37	.171509	7.43	.241286	8.73
743	7.68	.210020	8.93	38	.171955	7.42	.241810	8.72
204	7.68	.210556	8.92	39	.172400	7.43	.242333	8.73
665	7.68	9.211091	8.93	40	9.172846	7.42	9.242857	8.72
126	7.67	.211627	8.92	41	.173291	7.42	.243380	8.72
586	7.67	.212162	8.92	42	.173736	7.42	.243903	8.72
046	7.67	.212697	8.92	43	.174181	7.42	.244426	8.72
506	7.67	.213232	8.92	44	.174626	7.40	.244949	8.70
966	7.67	9.213767	8.90	45	9.175070	7.40	9.245471	8.72
425	7.65	.214301	8.92	46	.175514	7.40	.245994	8.70
884	7.65	.214836	8.90	47	.175958	7.40	.246516	8.70
343	7.65	.215370	8.90	48	.176402	7.38	.247038	8.68
801	7.63	.215904	8.88	49	.176845	7.38	.247559	8.70
259	7.63	9.216437	8.90	50	9.177288	7.38	9.248081	8.68
717	7.63	.216971	8.88	51	.177731	7.38	.248602	8.68
175	7.63	.217504	8.88	52	.178174	7.37	.249123	8.68
633	7.62	.218037	8.88	53	.178616	7.37	.249644	8.68
090	7.62	.218570	8.87	54	.179058	7.37	.250165	8.68
547	7.60	9.219102	8.88	55	9.179500	7.37	9.250686	8.67
003	7.62	.219635	8.87	56	.179942	7.35	.251206	8.67
460	7.60	.220167	8.87	57	.180383	7.37	.251726	8.67
916	7.60	.220699	8.87	58	.180825	7.33	.252246	8.67
372	7.60	.221231	8.85	59	.181265	7.35	.252766	8.67
828		9.221762		60	9.181706		9.253286	

32°					33°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	
0	9. 181706		9. 253286		0	9. 207714		9. 284122	
1	.182147	7.35	.253805	8.65	1	.208140	7.10	.284631	
2	.182587	7.33	.254324	8.65	2	.208566	7.10	.285139	
3	.183027	7.33	.254843	8.65	3	.208992	7.10	.285647	
4	.183466	7.32	.255362	8.65	4	.209418	7.08	.286155	
5	9. 183906	7.33	9. 255881	8.63	5	9. 209843	7.08	9. 286663	
6	.184345	7.32	.256399	8.65	6	.210268	7.08	.287170	
7	.184784	7.32	.25 18	8.63	7	.210693	7.08	.287678	
8	.185223	7.32	.257436	8.63	8	.211118	7.08	.288185	
9	.185662	7.32	.257954	8.62	9	.211543	7.07	.288692	
		7.30							
10	9. 186100		9. 258471		10	9. 211967		9. 289199	
11	.186538	7.30	.258989	8.63	11	.212391	7.07	.289705	
12	.186976	7.30	.259506	8.62	12	.212815	7.07	.290212	
13	.187413	7.28	.260023	8.62	13	.213239	7.07	.290718	
14	.187851	7.30	.260540	8.62	14	.213662	7.05	.291224	
15	9. 188288	7.28	9. 261057	8.62	15	9. 214085	7.05	9. 291730	
16	.188724	7.27	.261574	8.60	16	.214508	7.05	.292236	
17	.189161	7.28	.262090	8.60	17	.214931	7.05	.292742	
18	.189597	7.27	.262606	8.60	18	.215354	7.05	.293247	
19	.190034	7.28	.263122	8.60	19	.215776	7.03	.293753	
		7.25					7.03		
20	9. 190469		9. 263638	8.60	20	9. 216198		9. 294258	
21	.190905	7.27	.264154	8.58	21	.216620	7.03	.294763	
22	.191341	7.27	.264669	8.58	22	.217042	7.03	.295268	
23	.191776	7.25	.265184	8.60	23	.217463	7.02	.295772	
24	.192211	7.25	.265700	8.57	24	.217884	7.02	.296277	
25	9. 192645	7.23	9. 266214	8.58	25	9. 218305	7.02	9. 296781	
26	.193080	7.25	.266729	8.58	26	.218726	7.02	.297285	
27	.193514	7.23	.267244	8.57	27	.219146	7.00	.297789	
28	.193948	7.23	.267758	8.57	28	.219567	7.02	.298293	
29	.194382	7.23	.268272	8.57	29	.219987	7.00	.298797	
		7.22					7.00		
30	9. 194815		9. 268786	8.57	30	9. 220407	6.98	9. 299300	
31	.195249	7.23	.269300	8.57	31	.220826	7.00	.299803	
32	.195682	7.22	.269814	8.55	32	.221246	6.98	.300307	
33	.196115	7.22	.270327	8.55	33	.221665	6.98	.300809	
34	.196547	7.20	.270840	8.57	34	.222084	6.98	.301312	
35	9. 196980	7.22	9. 271354	8.53	35	9. 222503	6.97	9. 301815	
36	.197412	7.20	.271866	8.55	36	.222921	6.98	.302317	
37	.197844	7.20	.272379	8.55	37	.223340	6.97	.302820	
38	.198275	7.18	.272892	8.53	38	.223758	6.97	.303322	
39	.198707	7.20	.273404	8.53	39	.224176	6.95	.303824	
		7.18							
40	9. 199138		9. 273916	8.53	40	9. 224593	6.97	9. 304325	
41	.199569	7.18	.274428	8.53	41	.225011	6.95	.304827	
42	.200000	7.18	.274940	8.53	42	.225428	6.95	.305328	
43	.200430	7.17	.275452	8.52	43	.225845	6.95	.305830	
44	.200861	7.18	.275963	8.52	44	.226262	6.95	.306331	
45	9. 201291	7.17	9. 276474	8.53	45	9. 226678	6.93	9. 306832	
46	.201720	7.15	.276986	8.50	46	.227095	6.95	.307333	
47	.202150	7.17	.277496	8.52	47	.227511	6.93	.307833	
48	.202579	7.15	.278007	8.52	48	.227927	6.93	.308334	
49	.203008	7.15	.278518	8.50	49	.228342	6.92	.308834	
		7.15					6.93		
50	9. 203437		9. 279028	8.50	50	9. 228758	6.92	9. 309334	
51	.203866	7.15	.279538	8.50	51	.229173	6.92	.309834	
52	.204294	7.13	.280048	8.50	52	.229588	6.92	.310334	
53	.204723	7.15	.280558	8.50	53	.230003	6.92	.310834	
54	.205151	7.13	.281068	8.48	54	.230418	6.90	.311333	
55	9. 205578	7.13	9. 281577	8.50	55	9. 230832	6.90	9. 311832	
56	.206006	7.12	.282087	8.48	56	.231246	6.90	.312331	
57	.206433	7.12	.282596	8.48	57	.231660	6.90	.312830	
58	.206860	7.12	.283105	8.48	58	.232074	6.90	.313329	
59	.207287	7.12	.283614	8.47	59	.232487	6.88	.313828	
60	9. 207714		9. 284122		60	9. 232901	6.90	9. 314326	

's.	D. 1″.	Exsec.	D. 1″.
901	6.88	9.314326	8.32
314	6.88	.314825	8.30
727	6.87	.315323	8.30
739	6.88	.315821	8.30
552	6.87	.316319	8.30
964	6.87	9.316817	8.28
376	6.87	.317314	8.28
788	6.85	.317811	8.30
199	6.87	.318309	8.28
611	6.85	.318806	8.28
022	6.85	9.319303	8.27
433	6.85	.319799	8.28
844	6.83	.320296	8.27
254	6.85	.320792	8.28
665	6.83	.321289	8.27
075	6.83	9.321785	8.27
485	6.82	.322281	8.25
894	6.83	.322776	8.27
304	6.82	.323272	8.27
713	6.82	.323768	8.25
122	6.82	9.324263	8.25
531	6.82	.324758	8.25
940	6.80	.325253	8.25
348	6.80	.325748	8.25
756	6.80	.326243	8.23
164	6.80	9.326737	8.25
572	6.80	.327232	8.23
980	6.78	.327726	8.23
387	6.78	.328220	8.23
794	6.78	.328714	8.22
201	6.78	9.329207	8.23
608	6.77	.329701	8.23
014	6.78	.330195	8.22
421	6.77	.330688	8.22
827	6.77	.331181	8.22
233	6.77	9.331674	8.22
639	6.75	.332167	8.20
044	6.75	.332659	8.22
449	6.75	.333152	8.20
854	6.75	.333644	8.22
259	6.75	9.334137	8.20
664	6.73	.334629	8.20
068	6.75	.335121	8.18
473	6.73	.335612	8.20
877	6.73	.336104	8.18
281	6.72	9.336595	8.20
684	6.73	.337087	8.18
088	6.72	.337578	8.18
491	6.72	.338069	8.18
894	6.72	.338560	8.17
297	6.70	9.339050	8.18
699	6.72	.339541	8.17
102	6.70	.340031	8.18
504	6.70	.340522	8.17
906	6.70	.341012	8.17
308	6.68	9.341502	8.15
709	6.70	.341991	8.17
111	6.68	.342481	8.17
512	6.68	.342971	8.15
913	6.68	.343460	8.15
314		9.343949	

M.	Vers.	D. 1″.	Exsec.	D. 1″.
0	9.257314	6.67	9.343949	8.15
1	.257714	6.68	.344438	8.15
2	.258115	6.67	.344927	8.15
3	.258515	6.67	.345416	8.13
4	.258915	6.65	.345904	8.15
5	9.259314	6.67	9.346393	8.13
6	.259714	6.65	.346881	8.13
7	.260113	6.65	.347369	8.13
8	.260512	6.65	.347857	8.13
9	.260911	6.65	.348345	8.13
10	9.261310	6.65	9.348833	8.13
11	.261709	6.63	.349321	8.12
12	.262107	6.63	.349808	8.12
13	.262505	6.63	.350295	8.12
14	.262903	6.63	.350782	8.12
15	9.263301	6.62	9.351269	8.12
16	.263698	6.63	.351756	8.12
17	.264096	6.62	.352243	8.12
18	.264493	6.62	.352730	8.10
19	.264890	6.62	.353216	8.10
20	9.265287	6.60	9.353702	8.10
21	.265683	6.62	.354188	8.10
22	.266080	6.60	.354674	8.10
23	.266476	6.60	.355160	8.10
24	.266872	6.58	.355646	8.08
25	9.267267	6.60	9.356131	8.10
26	.267663	6.58	.356617	8.08
27	.268058	6.58	.357102	8.08
28	.268453	6.58	.357587	8.08
29	.268848	6.58	.358072	8.08
30	9.269243	6.58	9.358557	8.08
31	.269638	6.57	.359042	8.07
32	.270032	6.57	.359526	8.08
33	.270426	6.57	.360011	8.07
34	.270820	6.57	.360495	8.07
35	9.271214	6.57	9.360979	8.07
36	.271608	6.55	.361463	8.07
37	.272001	6.55	.361947	8.07
38	.272394	6.55	.362431	8.05
39	.272787	6.55	.362914	8.07
40	9.273180	6.53	9.363398	8.05
41	.273572	6.55	.363881	8.05
42	.273965	6.53	.364364	8.05
43	.274357	6.53	.364847	8.05
44	.274749	6.53	.365330	8.05
45	9.275141	6.52	9.365813	8.03
46	.275532	6.53	.366295	8.05
47	.275924	6.52	.366778	8.03
48	.276315	6.52	.367260	8.03
49	.276706	6.52	.367742	8.03
50	9.277097	6.52	9.368224	8.03
51	.277488	6.50	.368706	8.03
52	.277878	6.50	.369188	8.03
53	.278268	6.50	.369670	8.02
54	.278658	6.50	.370151	8.02
55	9.279048	6.50	9.370632	8.03
56	.279438	6.48	.371114	8.02
57	.279827	6.50	.371595	8.02
58	.280217	6.48	.372076	8.00
59	.280606	6.48	.372556	8.02
60	9.280995		9.373037	

36°					37°				
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	I
0	9.280995	6.47	9.373037	8.02	0	9.303983	6.28	9.401634	
1	.281383	6.48	.373518	8.00	1	.304360	6.30	.402107	
2	.281772	6.47	.373998	8.00	2	.304738	6.28	.402580	
3	.282160	6.47	.374478	8.00	3	.305115	6.28	.403052	
4	.282548	6.47	.374958	8.00	4	.305492	6.27	.403524	
5	9.282936	6.47	9.375438	8.00	5	9.305868	6.28	9.403997	
6	.283324	6.47	.375918	8.00	6	.306245	6.27	.404469	
7	.283712	6.45	.376398	7.98	7	.306621	6.28	.404941	
8	.284099	6.45	.376877	8.00	8	.306998	6.27	.405412	
9	.284486	6.45	.377357	7.98	9	.307374	6.25	.405884	
10	9.284873	6.45	9.377836	7.98	10	9.307749	6.27	9.406356	
11	.285260	6.45	.378315	7.98	11	.308125	6.27	.406827	
12	.285647	6.43	.378794	7.98	12	.308501	6.25	.407298	
13	.286033	6.43	.379273	7.98	13	.308876	6.25	.407770	
14	.286419	6.43	.379752	7.98	14	.309251	6.25	.408241	
15	9.286805	6.43	9.380231	7.97	15	9.309626	6.25	9.408712	
16	.287191	6.43	.380709	7.98	16	.310001	6.23	.409183	
17	.287577	6.42	.381188	7.97	17	.310375	6.25	.409653	
18	.287962	6.43	.381666	7.97	18	.310750	6.23	.410124	
19	.288348	6.42	.382144	7.97	19	.311124	6.23	.410594	
20	9.288733	6.42	9.382622	7.97	20	9.311498	6.23	9.411065	
21	.289118	6.40	.383100	7.95	21	.311872	6.22	.411535	
22	.289502	6.42	.383577	7.97	22	.312245	6.23	.412005	
23	.289887	6.40	.384055	7.95	23	.312619	6.22	.412475	
24	.290271	6.40	.384532	7.97	24	.312992	6.22	.412945	
25	9.290655	6.40	9.385010	7.95	25	9.313365	6.22	9.413415	
26	.291039	6.40	.385487	7.95	26	.313738	6.22	.413884	
27	.291423	6.40	.385964	7.95	27	.314111	6.22	.414354	
28	.291807	6.38	.386441	7.95	28	.314484	6.20	.414823	
29	.292190	6.38	.386918	7.93	29	.314856	6.20	.415293	
30	9.292573	6.38	9.387394	7.95	30	9.315228	6.20	9.415762	
31	.292956	6.38	.387871	7.93	31	.315600	6.20	.416231	
32	.293339	6.38	.388347	7.95	32	.315972	6.20	.416700	
33	.293722	6.37	.388824	7.93	33	.316344	6.20	.417168	
34	.294104	6.37	.389300	7.93	34	.316716	6.18	.417637	
35	9.294486	6.37	9.389776	7.93	35	9.317087	6.18	9.418106	
36	.294868	6.37	.390252	7.92	36	.317458	6.18	.418574	
37	.295250	6.37	.390727	7.93	37	.317829	6.18	.419042	
38	.295632	6.37	.391203	7.92	38	.318200	6.18	.419511	
39	.296014	6.35	.391678	7.93	39	.318571	6.17	.419979	
40	9.296395	6.35	9.392154	7.92	40	9.318941	6.17	9.420447	
41	.296776	6.35	.392629	7.92	41	.319311	6.18	.420915	
42	.297157	6.35	.393104	7.92	42	.319682	6.15	.421382	
43	.297538	6.33	.393579	7.92	43	.320051	6.17	.421850	
44	.297918	6.35	.394054	7.92	44	.320421	6.17	.422317	
45	9.298299	6.33	9.394529	7.90	45	9.320791	6.15	9.422785	
46	.298679	6.33	.395003	7.92	46	.321160	6.17	.423252	
47	.299059	6.33	.395478	7.90	47	.321530	6.15	.423719	
48	.299439	6.33	.395952	7.90	48	.321899	6.13	.424186	
49	.299819	6.32	.396426	7.90	49	.322267	6.15	.424653	
50	9.300198	6.32	9.396900	7.90	50	9.322636	6.15	9.425120	
51	.300577	6.33	.397374	7.90	51	.323005	6.13	.425587	
52	.300957	6.30	.397848	7.90	52	.323373	6.13	.426053	
53	.301335	6.32	.398322	7.88	53	.323741	6.13	.426520	
54	.301714	6.32	.398795	7.90	54	.324109	6.13	.426986	
55	9.302093	6.30	9.399269	7.88	55	9.324477	6.13	9.427452	
56	.302471	6.30	.399742	7.88	56	.324845	6.12	.427918	
57	.302849	6.30	.400215	7.88	57	.325212	6.13	.428384	
58	.303227	6.30	.400688	7.88	58	.325580	6.12	.428850	
59	.303605	6.30	.401161	7.88	59	.325947	6.12	.429316	
60	9.303983		9.401634		60	9.326314		9.429782	

	38°				39°				
L.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
	9.326314	6.12	9.429782	7.75	0	9.348021	5.93	9.457518	7.65
	.326681	6.10	.430247	7.77	1	.348377	5.95	.457977	7.65
	.327047	6.12	.430713	7.75	2	.348734	5.93	.458436	7.65
	.327414	6.10	.431178	7.75	3	.349090	5.93	.458895	7.63
	.327780	6.10	.431643	7.75	4	.349446	5.93	.459353	7.65
	9.328146	6.10	9.432108	7.75	5	9.349802	5.93	9.459812	7.63
	.328512	6.10	.432573	7.75	6	.350158	5.93	.460270	7.65
	.328878	6.08	.433038	7.75	7	.350514	5.92	.460729	7.63
	.329243	6.10	.433503	7.73	8	.350869	5.93	.461187	7.63
	.329609	6.08	.433967	7.75	9	.351225	5.92	.461645	7.63
	9.329974	6.08	9.434432	7.73	10	9.351580	5.92	9.462103	7.63
	.330339	6.08	.434896	7.75	11	.351935	5.92	.462561	7.63
	.330704	6.08	.435361	7.73	12	.352290	5.90	.463019	7.63
	.331069	6.07	.435825	7.73	13	.352644	5.92	.463477	7.62
	.331433	6.08	.436289	7.73	14	.352999	5.90	.463934	7.63
	9.331798	6.07	9.436753	7.73	15	9.353353	5.90	9.464392	7.62
	.332162	6.07	.437217	7.72	16	.353707	5.92	.464849	7.63
	.332526	6.07	.437680	7.73	17	.354062	5.88	.465307	7.62
	.332890	6.07	.438144	7.73	18	.354415	5.90	.465764	7.62
	.333254	6.05	.438608	7.72	19	.354769	5.90	.466221	7.62
	9.333617	6.07	9.439071	7.72	20	9.355123	5.88	9.466678	7.62
	.333981	6.05	.439534	7.72	21	.355476	5.88	.467135	7.62
	.334344	6.05	.439997	7.72	22	.355829	5.88	.467592	7.62
	.334707	6.05	.440460	7.72	23	.356182	5.88	.468049	7.62
	.335070	6.03	.440923	7.72	24	.356535	5.88	.468506	7.60
	9.335432	6.05	9.441386	7.72	25	9.356888	5.88	9.468962	7.60
	.335795	6.03	.441849	7.72	26	.357241	5.87	.469418	7.62
	.336157	6.03	.442312	7.70	27	.357593	5.87	.469875	7.60
	.336519	6.03	.442774	7.72	28	.357945	5.87	.470331	7.60
	.336881	6.03	.443237	7.70	29	.358297	5.87	.470787	7.60
	9.337243	6.03	9.443699	7.70	30	9.358649	5.87	9.471243	7.60
	.337605	6.02	.444161	7.70	31	.359001	5.87	.471699	7.60
	.337966	6.03	.444623	7.70	32	.359353	5.85	.472155	7.60
	.338328	6.02	.445085	7.70	33	.359704	5.87	.472611	7.60
	.338689	6.02	.445547	7.70	34	.360056	5.85	.473067	7.58
	9.339050	6.02	9.446009	7.68	35	9.360407	5.85	9.473522	7.60
	.339411	6.00	.446470	7.70	36	.360758	5.83	.473978	7.58
	.339771	6.02	.446932	7.68	37	.361108	5.85	.474433	7.58
	.340132	6.00	.447393	7.70	38	.361459	5.85	.474888	7.58
	.340492	6.00	.447855	7.68	39	.361810	5.83	.475343	7.58
	9.340852	6.00	9.448316	7.68	40	9.362160	5.83	9.475798	7.58
	.341212	6.00	.448777	7.68	41	.362510	5.83	.476253	7.58
	.341572	6.00	.449238	7.68	42	.362860	5.83	.476708	7.58
	.341932	5.98	.449699	7.68	43	.363210	5.83	.477163	7.58
	.342291	6.00	.450160	7.67	44	.363560	5.82	.477618	7.57
	9.342651	5.98	9.450620	7.68	45	9.363909	5.83	9.478072	7.57
	.343010	5.98	.451081	7.67	46	.364259	5.82	.478527	7.57
	.343369	5.98	.451541	7.68	47	.364608	5.82	.478981	7.57
	.343728	5.97	.452002	7.67	48	.364957	5.82	.479435	7.58
	.344086	5.98	.452462	7.67	49	.365306	5.82	.479890	7.57
	9.344445	5.97	9.452922	7.67	50	9.365655	5.80	9.480344	7.57
	.344803	5.97	.453382	7.67	51	.366003	5.82	.480798	7.57
	.345161	5.97	.453842	7.67	52	.366352	5.80	.481252	7.55
	.345519	5.97	.454302	7.67	53	.366700	5.80	.481705	7.57
	.345877	5.97	.454762	7.65	54	.367048	5.80	.482159	7.57
	9.346235	5.95	9.455221	7.67	55	9.367396	5.80	9.482613	7.55
	.346592	5.97	.455681	7.65	56	.367744	5.78	.483066	7.57
	.346950	5.95	.456140	7.67	57	.368091	5.80	.483520	7.55
	.347307	5.95	.456600	7.65	58	.368439	5.78	.483973	7.55
	.347664	5.95	.457059	7.65	59	.368786	5.78	.484426	7.55
	9.348021		9.457518		60	9.369133		9.484879	

40°					41°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.
0	9.369133	5.78	9.484879	7.55	0	9.389681	5.62	9.511901
1	.369480	5.78	.485332	7.55	1	.390018	5.63	.512348
2	.369827	5.78	.485785	7.55	2	.390356	5.63	.512796
3	.370174	5.77	.486238	7.55	3	.390694	5.62	.513243
4	.370520	5.78	.486691	7.55	4	.391031	5.62	.513691
5	9.370867	5.77	9.487144	7.53	5	9.391368	5.62	9.514138
6	.371213	5.77	.487596	7.55	6	.391705	5.62	.514585
7	.371559	5.77	.488049	7.53	7	.392042	5.62	.515033
8	.371905	5.77	.488501	7.53	8	.392379	5.62	.515480
9	.372251	5.75	.488953	7.55	9	.392716	5.60	.515927
10	9.372596	5.77	9.489406	7.53	10	9.393052	5.60	9.516374
11	.372942	5.75	.489858	7.53	11	.393388	5.60	.516820
12	.373287	5.75	.490310	7.53	12	.393724	5.62	.517267
13	.373632	5.75	.490762	7.53	13	.394061	5.58	.517714
14	.373977	5.75	.491214	7.53	14	.394396	5.60	.518160
15	9.374322	5.75	9.491665	7.52	15	9.394732	5.60	9.518607
16	.374667	5.75	.492117	7.53	16	.395068	5.60	.519053
17	.375011	5.73	.492569	7.53	17	.395403	5.58	.519500
18	.375356	5.75	.493020	7.52	18	.395738	5.58	.519946
19	.375700	5.73	.493471	7.52	19	.396074	5.60	.520392
20	9.376044	5.73	9.493923	7.53	20	9.396409	5.58	9.520838
21	.376388	5.73	.494374	7.52	21	.396743	5.57	.521284
22	.376732	5.73	.494825	7.52	22	.397078	5.58	.521730
23	.377075	5.72	.495276	7.52	23	.397413	5.58	.522176
24	.377419	5.73	.495727	7.52	24	.397747	5.57	.522621
25	9.377762	5.72	9.496178	7.52	25	9.398081	5.57	9.523067
26	.378105	5.72	.496628	7.50	26	.398415	5.57	.523513
27	.378448	5.72	.497079	7.52	27	.398749	5.57	.523958
28	.378791	5.72	.497530	7.52	28	.399083	5.57	.524404
29	.379133	5.70	.497980	7.50	29	.399417	5.57	.524849
30	9.379476	5.72	9.498430	7.50	30	9.399750	5.55	9.525294
31	.379818	5.70	.498881	7.52	31	.400084	5.57	.525739
32	.380161	5.72	.499331	7.50	32	.400417	5.55	.526184
33	.380503	5.70	.499781	7.50	33	.400750	5.55	.526629
34	.380845	5.70	.500231	7.50	34	.401083	5.55	.527074
35	9.381186	5.68	9.500681	7.50	35	9.401416	5.55	9.527519
36	.381528	5.70	.501131	7.50	36	.401748	5.53	.527964
37	.381869	5.68	.501581	7.50	37	.402081	5.55	.528409
38	.382211	5.70	.502030	7.48	38	.402413	5.53	.528853
39	.382552	5.68	.502480	7.50	39	.402745	5.53	.529298
40	9.382893	5.68	9.502929	7.48	40	9.403077	5.53	9.529742
41	.383234	5.67	.503379	7.50	41	.403409	5.53	.530187
42	.383574	5.68	.503828	7.48	42	.403741	5.53	.530631
43	.383915	5.67	.504277	7.48	43	.404073	5.53	.531075
44	.384255	5.67	.504726	7.48	44	.404404	5.52	.531519
45	9.384595	5.67	9.505175	7.48	45	9.404736	5.53	9.531963
46	.384935	5.67	.505624	7.48	46	.405067	5.52	.532407
47	.385275	5.67	.506073	7.48	47	.405398	5.52	.532851
48	.385615	5.67	.506522	7.48	48	.405729	5.52	.533295
49	.385955	5.65	.506971	7.47	49	.406059	5.50	.533739
50	9.386294	5.67	9.507419	7.48	50	9.406390	5.52	9.534182
51	.386634	5.65	.507868	7.47	51	.406721	5.50	.534626
52	.386973	5.65	.508316	7.48	52	.407051	5.50	.535070
53	.387312	5.65	.508765	7.47	53	.407381	5.50	.535513
54	.387651	5.63	.509213	7.47	54	.407711	5.50	.535956
55	9.387989	5.65	9.509661	7.47	55	9.408041	5.50	9.536400
56	.388328	5.63	.510109	7.47	56	.408371	5.48	.536843
57	.388666	5.65	.510557	7.47	57	.408700	5.50	.537286
58	.389005	5.63	.511005	7.47	58	.409030	5.48	.537729
59	.389343	5.63	.511453	7.47	59	.409359	5.48	.538171
60	9.389681		9.511901		60	9.409688		9.538615

	42°					43°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
0	9.409688	5.48	9.538615	7.38	0	9.429181	5.35	9.565053	7.32
1	.410017	5.48	.539058	7.37	1	.429502	5.33	.565492	7.30
2	.410346	5.48	.539500	7.38	2	.429822	5.33	.565930	7.32
3	.410675	5.48	.539943	7.38	3	.430142	5.33	.566369	7.30
4	.411004	5.47	.540386	7.37	4	.430463	5.35	.566807	7.30
5	9.411332	5.47	9.540828	7.38	5	9.430783	5.33	9.567245	7.30
6	.411660	5.48	.541271	7.37	6	.431103	5.33	.567683	7.30
7	.411989	5.47	.541713	7.37	7	.431422	5.32	.568121	7.30
8	.412317	5.45	.542155	7.37	8	.431742	5.33	.568559	7.30
9	.412644	5.47	.542597	7.38	9	.432062	5.33	.568997	7.30
10	9.412972	5.47	9.543040	7.37	10	9.432381	5.32	9.569435	7.30
11	.413300	5.45	.543482	7.37	11	.432700	5.33	.569873	7.30
12	.413627	5.47	.543924	7.37	12	.433020	5.32	.570311	7.28
13	.413955	5.45	.544366	7.35	13	.433339	5.30	.570748	7.30
14	.414282	5.45	.544807	7.37	14	.433657	5.32	.571186	7.30
15	9.414609	5.45	9.545249	7.37	15	9.433976	5.32	9.571624	7.28
16	.414936	5.45	.545691	7.35	16	.434295	5.30	.572061	7.28
17	.415262	5.43	.546132	7.37	17	.434613	5.32	.572498	7.30
18	.415589	5.45	.546574	7.35	18	.434932	5.30	.572936	7.28
19	.415916	5.45	.547015	7.37	19	.435250	5.30	.573373	7.28
20	9.416242	5.43	9.547457	7.35	20	9.435568	5.30	9.573810	7.28
21	.416568	5.43	.547898	7.35	21	.435886	5.30	.574247	7.30
22	.416894	5.43	.548339	7.37	22	.436204	5.28	.574685	7.28
23	.417220	5.43	.548781	7.35	23	.436521	5.30	.575122	7.27
24	.417546	5.42	.549222	7.35	24	.436839	5.28	.575558	7.28
25	9.417871	5.43	9.549663	7.35	25	9.437156	5.28	9.575995	7.28
26	.418197	5.42	.550104	7.33	26	.437473	5.30	.576432	7.28
27	.418522	5.43	.550544	7.35	27	.437791	5.27	.576869	7.28
28	.418848	5.42	.550985	7.35	28	.438107	5.28	.577306	7.27
29	.419173	5.42	.551426	7.35	29	.438424	5.28	.577742	7.28
30	9.419498	5.40	9.551867	7.33	30	9.438741	5.28	9.578179	7.27
31	.419822	5.42	.552307	7.35	31	.439058	5.27	.578615	7.28
32	.420147	5.40	.552748	7.33	32	.439374	5.27	.579052	7.27
33	.420471	5.42	.553188	7.35	33	.439690	5.28	.579488	7.27
34	.420796	5.40	.553629	7.33	34	.440007	5.27	.579924	7.28
35	9.421120	5.40	9.554069	7.33	35	9.440323	5.27	9.580361	7.27
36	.421444	5.40	.554509	7.33	36	.440639	5.25	.580797	7.27
37	.421768	5.40	.554949	7.33	37	.440954	5.27	.581233	7.27
38	.422092	5.40	.555389	7.33	38	.441270	5.27	.581669	7.27
39	.422416	5.38	.555829	7.33	39	.441586	5.25	.582105	7.27
40	9.422739	5.40	9.556269	7.33	40	9.441901	5.25	9.582541	7.27
41	.423063	5.38	.556709	7.33	41	.442216	5.25	.582977	7.27
42	.423386	5.38	.557149	7.33	42	.442531	5.25	.583413	7.25
43	.423709	5.38	.557589	7.32	43	.442846	5.25	.583848	7.27
44	.424032	5.38	.558028	7.33	44	.443161	5.25	.584284	7.27
45	9.424355	5.37	9.558468	7.32	45	9.443476	5.23	9.584720	7.25
46	.424677	5.38	.558907	7.33	46	.443790	5.25	.585155	7.27
47	.425000	5.37	.559347	7.32	47	.444105	5.23	.585591	7.25
48	.425322	5.38	.559786	7.33	48	.444419	5.23	.586026	7.27
49	.425645	5.37	.560226	7.32	49	.444733	5.23	.586462	7.25
50	.425967	5.37	9.560665	7.32	50	9.445047	5.23	9.586897	7.25
51	.426289	5.37	.561104	7.32	51	.445361	5.23	.587332	7.25
52	.426611	5.37	.561543	7.32	52	.445675	5.23	.587767	7.27
53	.426933	5.35	.561982	7.32	53	.445989	5.22	.588203	7.25
54	.427254	5.37	.562421	7.32	54	.446302	5.23	.588638	7.25
55	.427576	5.35	9.562860	7.32	55	9.446616	5.22	9.589073	7.25
56	.427897	5.35	.563299	7.32	56	.446929	5.22	.589508	7.23
57	.428218	5.35	.563738	7.30	57	.447242	5.22	.589942	7.25
58	.428539	5.35	.564176	7.32	58	.447555	5.22	.590377	7.25
59	.428860	5.35	.564615	7.30	59	.447868	5.22	.590812	7.25
60	.429181		9.565053		60	9.448181		9.591247	

44°					45°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.
0	9.448181		9.591247		0	9.466709		9.617224
1	.448493	5.20	.591681	7.23	1	.467014	5.08	.617656
2	.448806	5.22	.592116	7.25	2	.467319	5.08	.618087
3	.449118	5.20	.592551	7.25	3	.467624	5.08	.618518
4	.449431	5.22	.592985	7.23	4	.467928	5.07	.618949
5	9.449743	5.20	9.593419	7.23	5	9.468233	5.08	9.619380
6	.450055	5.20	.593854	7.25	6	.468537	5.07	.619811
7	.450366	5.18	.594288	7.23	7	.468841	5.07	.620242
8	.450678	5.20	.594722	7.23	8	.469145	5.07	.620673
9	.450990	5.20	.595156	7.23	9	.469449	5.07	.621104
		5.18		7.25			5.07	
10	9.451301		9.595591		10	9.469753		9.621535
11	.451612	5.18	.596025	7.23	11	.470057	5.07	.621966
12	.451924	5.20	.596459	7.23	12	.470360	5.05	.622396
13	.452235	5.18	.596893	7.23	13	.470664	5.07	.622827
14	.452546	5.18	.597326	7.22	14	.470967	5.05	.623258
15	9.452856	5.17	9.597760	7.23	15	9.471270	5.05	9.623688
16	.453167	5.18	.598194	7.23	16	.471573	5.05	.624119
17	.453478	5.18	.598628	7.23	17	.471876	5.05	.624549
18	.453788	5.17	.599061	7.22	18	.472179	5.05	.624980
19	.454098	5.17	.599495	7.23	19	.472482	5.05	.625410
		5.17		7.22			5.03	
20	9.454408		9.599928		20	9.472784		9.625841
21	.454718	5.17	.600362	7.23	21	.473087	5.05	.626271
22	.455028	5.17	.600795	7.22	22	.473389	5.03	.626701
23	.455338	5.17	.601229	7.23	23	.473691	5.03	.627131
24	.455648	5.17	.601662	7.22	24	.473993	5.03	.627561
25	9.455957	5.15	9.602095	7.22	25	9.474295	5.03	9.627991
26	.456267	5.17	.602528	7.22	26	.474597	5.03	.628421
27	.456576	5.15	.602962	7.23	27	.474899	5.03	.628851
28	.456885	5.15	.603395	7.22	28	.475200	5.02	.629281
29	.457194	5.15	.603828	7.22	29	.475502	5.03	.629711
		5.15		7.22			5.02	
30	9.457503		9.604261		30	9.475803		9.630141
31	.457811	5.13	.604694	7.22	31	.476104	5.02	.630571
32	.458120	5.15	.605126	7.20	32	.476405	5.02	.631001
33	.458429	5.15	.605559	7.22	33	.476706	5.02	.631430
34	.458737	5.13	.605992	7.22	34	.477007	5.02	.631860
35	9.459045	5.13	9.606425	7.22	35	9.477308	5.02	9.632290
36	.459353	5.13	.606857	7.20	36	.477608	5.00	.632719
37	.459661	5.13	.607290	7.22	37	.477909	5.02	.633149
38	.459969	5.13	.607722	7.20	38	.478209	5.00	.633578
39	.460277	5.13	.608155	7.22	39	.478509	5.00	.634008
		5.12		7.20			5.00	
40	9.460584		9.608587		40	9.478809		9.634437
41	.460892	5.13	.609020	7.22	41	.479109	5.00	.634866
42	.461199	5.12	.609452	7.20	42	.479409	5.00	.635296
43	.461506	5.12	.609884	7.20	43	.479709	5.00	.635725
44	.461813	5.12	.610316	7.20	44	.480009	4.98	.636154
45	9.462120	5.12	9.610749	7.22	45	9.480308	5.00	9.636583
46	.462427	5.12	.611181	7.20	46	.480608	4.98	.637012
47	.462734	5.12	.611613	7.20	47	.480907	4.98	.637441
48	.463040	5.10	.612045	7.20	48	.481206	4.98	.637870
49	.463347	5.12	.612477	7.20	49	.481505	4.98	.638299
		5.10		7.18				
50	9.463653		9.612908		50	9.481804	4.98	9.638728
51	.463959	5.10	.613340	7.20	51	.482103	4.97	.639157
52	.464265	5.10	.613772	7.20	52	.482401	4.98	.639586
53	.464571	5.10	.614204	7.20	53	.482700	4.97	.640015
54	.464877	5.10	.614635	7.18	54	.482998	4.97	.640443
55	9.465183	5.10	9.615067	7.20	55	9.483296	4.97	9.640872
56	.465488	5.08	.615499	7.20	56	.483595	4.98	.641301
57	.465794	5.10	.615930	7.18	57	.483893	4.97	.641729
58	.466099	5.08	.616362	7.20	58	.484191	4.97	.642158
59	.466404	5.08	.616793	7.18	59	.484488	4.95	.642
60	9.466709	5.08	9.617224	7.18	60	9.484786	4.97	9.643

46°				47°				
Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
9.484786	4.97	9.643015	7.13	0	9.502429	4.85	9.668646	7.10
.485084	4.95	.643443	7.15	1	.502720	4.83	.669072	7.10
.485381	4.95	.643872	7.13	2	.503010	4.83	.669498	7.10
.485678	4.95	.644300	7.13	3	.503300	4.85	.669924	7.10
.485976	4.97	.644728	7.13	4	.503591	4.83	.670350	7.10
9.486273	4.95	9.645156	7.15	5	9.503881	4.83	9.670776	7.08
.486570	4.95	.645585	7.13	6	.504171	4.82	.671201	7.10
.486866	4.93	.646013	7.13	7	.504460	4.83	.671627	7.10
.487163	4.95	.646441	7.13	8	.504750	4.83	.672053	7.10
.487460	4.95	.646869	7.13	9	.505040	4.82	.672479	7.08
9.487756	4.95	9.647297	7.13	10	9.505329	4.82	9.672904	7.10
.488053	4.93	.647725	7.13	11	.505618	4.83	.673330	7.10
.488349	4.93	.648153	7.13	12	.505908	4.82	.673756	7.08
.488645	4.93	.648581	7.13	13	.506197	4.82	.674181	7.10
.488941	4.93	.649009	7.12	14	.506486	4.82	.674607	7.08
9.489237	4.93	9.649436	7.13	15	9.506775	4.80	9.675032	7.10
.489533	4.92	.649864	7.13	16	.507063	4.82	.675458	7.08
.489828	4.93	.650292	7.13	17	.507352	4.80	.675883	7.10
.490124	4.92	.650720	7.12	18	.507640	4.82	.676309	7.08
.490419	4.92	.651147	7.13	19	.507929	4.80	.676734	7.08
9.490714	4.93	9.651575	7.12	20	9.508217	4.80	9.677159	7.08
.491010	4.92	.652002	7.13	21	.508505	4.80	.677584	7.10
.491305	4.92	.652430	7.12	22	.508793	4.80	.678010	7.08
.491600	4.90	.652857	7.13	23	.509081	4.80	.678435	7.08
.491894	4.92	.653285	7.12	24	.509369	4.80	.678860	7.08
9.492189	4.92	9.653712	7.13	25	9.509657	4.80	9.679285	7.08
.492484	4.90	.654140	7.12	26	.509945	4.78	.679710	7.10
.492778	4.90	.654567	7.12	27	.510232	4.80	.680136	7.08
.493072	4.92	.654994	7.12	28	.510520	4.78	.680561	7.08
.493367	4.90	.655421	7.13	29	.510807	4.78	.680986	7.08
9.493661	4.90	9.655849	7.12	30	9.511094	4.78	9.681411	7.08
.493955	4.90	.656276	7.12	31	.511381	4.78	.681836	7.07
.494249	4.88	.656703	7.12	32	.511668	4.78	.682260	7.08
.494542	4.90	.657130	7.12	33	.511955	4.77	.682685	7.08
.494836	4.90	.657557	7.12	34	.512241	4.78	.683110	7.08
9.495130	4.88	9.657984	7.12	35	9.512528	4.78	9.683535	7.08
.495423	4.88	.658411	7.12	36	.512815	4.77	.683960	7.08
.495716	4.88	.658838	7.12	37	.513101	4.77	.684385	7.07
.496009	4.88	.659265	7.10	38	.513387	4.77	.684809	7.08
.496302	4.88	.659691	7.12	39	.513673	4.77	.685234	7.08
9.496595	4.88	9.660118	7.12	40	9.513959	4.77	9.685659	7.07
.496888	4.88	.660545	7.12	41	.514245	4.77	.686083	7.08
.497181	4.87	.660972	7.10	42	.514531	4.77	.686508	7.08
.497473	4.88	.661398	7.12	43	.514817	4.75	.686933	7.07
.497766	4.87	.661825	7.12	44	.515102	4.77	.687357	7.08
9.498058	4.87	9.662252	7.10	45	9.515388	4.75	9.687782	7.07
.498350	4.88	.662678	7.12	46	.515673	4.77	.688206	7.08
.498643	4.87	.663105	7.10	47	.515959	4.75	.688631	7.07
.498935	4.85	.663531	7.12	48	.516244	4.75	.689055	7.07
.499226	4.87	.663958	7.10	49	.516529	4.75	.689479	7.08
9.499518	4.87	9.664384	7.10	50	9.516814	4.73	9.689904	7.07
.499810	4.85	.664810	7.12	51	.517098	4.75	.690328	7.07
.500101	4.87	.665237	7.10	52	.517383	4.75	.690752	7.08
.500393	4.85	.665663	7.10	53	.517668	4.73	.691177	7.07
.500684	4.85	.666089	7.10	54	.517952	4.73	.691601	7.07
9.500975	4.85	9.666515	7.12	55	9.518236	4.75	9.692025	7.07
.501266	4.85	.666942	7.10	56	.518521	4.73	.692449	7.07
.501557	4.85	.667368	7.10	57	.518805	4.73	.692873	7.08
.501848	4.85	.667794	7.10	58	.519089	4.73	.693298	7.07
.502139	4.83	.668220	7.10	59	.519373	4.73	.693722	7.07
9.502429		9.668646		60	9.519657		.694146	

48°					49		
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″
0	9.519657	4.72	9.694146	7.07	0	9.536484	4.62
1	.519940	4.73	.694570	7.07	1	.536761	4.62
2	.520224	4.72	.694994	7.07	2	.537038	4.62
3	.520507	4.73	.695418	7.07	3	.537315	4.62
4	.520791	4.72	.695842	7.07	4	.537592	4.62
5	9.521074	4.72	9.696266	7.05	5	9.537869	4.60
6	.521357	4.72	.696689	7.07	6	.538145	4.62
7	.521640	4.72	.697113	7.07	7	.538422	4.60
8	.521923	4.72	.697537	7.07	8	.538698	4.60
9	.522206	4.70	.697961	7.07	9	.538974	4.62
10	9.522488	4.72	9.698385	7.07	10	9.539251	4.60
11	.522771	4.72	.698809	7.05	11	.539527	4.60
12	.523054	4.70	.699232	7.07	12	.539803	4.60
13	.523336	4.70	.699656	7.07	13	.540079	4.58
14	.523618	4.70	.700080	7.05	14	.540354	4.60
15	9.523900	4.70	9.700503	7.07	15	9.540630	4.60
16	.524182	4.70	.700927	7.05	16	.540906	4.58
17	.524464	4.70	.701350	7.07	17	.541181	4.58
18	.524746	4.70	.701774	7.07	18	.541456	4.60
19	.525028	4.68	.702198	7.05	19	.541732	4.58
20	9.525309	4.70	9.702621	7.07	20	9.542007	4.58
21	.525591	4.68	.703045	7.05	21	.542282	4.58
22	.525872	4.68	.703468	7.05	22	.542557	4.58
23	.526153	4.70	.703891	7.07	23	.542832	4.57
24	.526435	4.68	.704315	7.05	24	.543106	4.58
25	9.526716	4.68	9.704738	7.07	25	9.543381	4.57
26	.526997	4.67	.705162	7.05	26	.543655	4.58
27	.527277	4.68	.705585	7.05	27	.543930	4.57
28	.527558	4.68	.706008	7.05	28	.544204	4.57
29	.527839	4.67	.706431	7.07	29	.544478	4.57
30	9.528119	4.68	9.706855	7.05	30	9.544752	4.57
31	.528400	4.67	.707278	7.05	31	.545026	4.57
32	.528680	4.67	.707701	7.05	32	.545300	4.57
33	.528960	4.67	.708124	7.05	33	.545574	4.57
34	.529240	4.67	.708547	7.07	34	.545848	4.55
35	9.529520	4.67	9.708971	7.05	35	9.546121	4.57
36	.529800	4.67	.709394	7.05	36	.546395	4.55
37	.530080	4.65	.709817	7.05	37	.546668	4.55
38	.530359	4.67	.710240	7.05	38	.546941	4.55
39	.530639	4.65	.710663	7.05	39	.547214	4.55
40	9.530918	4.67	9.711086	7.05	40	9.547487	4.55
41	.531198	4.65	.711509	7.05	41	.547760	4.55
42	.531477	4.65	.711932	7.05	42	.548033	4.55
43	.531756	4.65	.712355	7.05	43	.548306	4.55
44	.532035	4.65	.712778	7.03	44	.548579	4.53
45	9.532314	4.63	9.713200	7.05	45	9.548851	4.55
46	.532592	4.65	.713623	7.05	46	.549124	4.53
47	.532871	4.65	.714046	7.05	47	.549396	4.53
48	.533150	4.63	.714469	7.05	48	.549668	4.53
49	.533428	4.63	.714892	7.05	49	.549940	4.53
50	9.533706	4.65	9.715315	7.03	50	9.550212	4.53
51	.533985	4.63	.715737	7.05	51	.550484	4.53
52	.534263	4.63	.716160	7.05	52	.550756	4.53
53	.534541	4.63	.716583	7.03	53	.551028	4.52
54	.534819	4.63	.717005	7.05	54	.551299	4.53
55	9.535097	4.62	9.717428	7.05	55	9.551571	4.52
56	.535374	4.63	.717851	7.03	56	.551842	4.52
57	.535652	4.62	.718273	7.05	57	.552113	4.52
58	.535929	4.63	.718696	7.03	58	.552384	4.5
59	.536207	4.62	.719118	7.05	59	.552656	4.
60	9.536484		9.719541		60	9.552927	

	50°			51°				
	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
	4.50	9.744859	7.02	0	9.568999	4.42	9.770127	7.02
	4.52	.745280	7.03	1	.569264	4.40	.770548	7.02
	4.52	.745702	7.02	2	.569528	4.42	.770969	7.00
	4.52	.746123	7.03	3	.569793	4.40	.771389	7.02
	4.50	.746545	7.02	4	.570057	4.42	.771810	7.02
	4.52	9.746966	7.03	5	9.570322	4.40	9.772231	7.02
	4.50	.747388	7.02	6	.570586	4.40	.772652	7.02
	4.50	.747809	7.02	7	.570850	4.40	.773073	7.02
	4.52	.748230	7.03	8	.571114	4.40	.773494	7.00
	4.50	.748652	7.02	9	.571378	4.40	.773914	7.02
	4.50							
	4.48	9.749073	7.02	10	9.571642	4.40	9.774335	7.02
	4.50	.749494	7.03	11	.571906	4.40	.774756	7.02
	4.50	.749916	7.02	12	.572170	4.40	.775177	7.02
	4.48	.750337	7.02	13	.572434	4.38	.775598	7.00
	4.50	.750758	7.03	14	.572697	4.38	.776018	7.02
	4.48	9.751180	7.02	15	9.572960	4.40	9.776439	7.02
	4.48	.751601	7.02	16	.573224	4.38	.776860	7.02
	4.48	.752022	7.02	17	.573487	4.38	.777281	7.02
	4.48	.752443	7.03	18	.573750	4.38	.777702	7.00
	4.48	.752865	7.02	19	.574013	4.38	.778122	7.02
	4.48	9.753286	7.02	20	9.574276	4.38	9.778543	7.02
	4.48	.753707	7.02	21	.574539	4.38	.778964	7.02
	4.48	.754128	7.02	22	.574802	4.37	.779385	7.00
	4.47	.754549	7.03	23	.575064	4.38	.779805	7.02
	4.47	.754971	7.02	24	.575327	4.37	.780226	7.02
	4.48	9.755392	7.02	25	9.575589	4.38	9.780647	7.02
	4.47	.755813	7.02	26	.575852	4.37	.781068	7.00
	4.47	.756234	7.02	27	.576114	4.37	.781488	7.02
	4.47	.756655	7.02	28	.576376	4.37	.781909	7.02
	4.47	.757076	7.03	29	.576638	4.37	.782330	7.02
	4.47	9.757498	7.02	30	9.576900	4.37	9.782751	7.00
	4.47	.757919	7.02	31	.577162	4.37	.783171	7.02
	4.45	.758340	7.02	32	.577424	4.37	.783592	7.02
	4.47	.758761	7.02	33	.577685	4.35	.784013	7.00
	4.45	.759182	7.02	34	.577947	4.37	.784433	7.02
	4.45	9.759603	7.02	35	9.578208	4.35	9.784854	7.02
	4.47	.760024	7.02	36	.578470	4.37	.785275	7.02
	4.45	.760445	7.02	37	.578731	4.35	.785696	7.00
	4.45	.760866	7.02	38	.578992	4.35	.786116	7.02
	4.45	.761287	7.02	39	.579253	4.35	.786537	7.02
	4.43	9.761708	7.02	40	9.579514	4.35	9.786958	7.00
	4.45	.762129	7.02	41	.579775	4.35	.787378	7.02
	4.45	.762550	7.02	42	.580036	4.35	.787799	7.02
	4.43	.762971	7.02	43	.580297	4.35	.788220	7.02
	4.45	.763392	7.02	44	.580557	4.33	.788641	7.00
	4.43	9.763813	7.02	45	9.580818	4.35	9.789061	7.02
	4.43	.764234	7.02	46	.581078	4.33	.789482	7.02
	4.43	.764655	7.02	47	.581339	4.35	.789903	7.00
	4.43	.765076	7.02	48	.581599	4.33	.790323	7.02
	4.43	.765497	7.02	49	.581859	4.33	.790744	7.02
	4.43	9.765918	7.02	50	9.582119	4.33	9.791165	7.02
	4.43	.766339	7.02	51	.582379	4.33	.791586	7.00
	4.42	.766760	7.02	52	.582639	4.32	.792006	7.02
	4.43	.767181	7.02	53	.582898	4.33	.792427	7.02
	4.42	.767602	7.00	54	.583158	4.33	.792848	7.00
	4.42	9.768022	7.02	55	9.583418	4.32	9.793268	7.02
	4.43	.768443	7.02	56	.583677	4.32	.793689	7.02
	4.42	.768864	7.02	57	.583936	4.33	.794110	7.02
	4.42	.769285	7.02	58	.584196	4.32	.794531	7.00
	4.42	.769706	7.02	59	.584455	4.32	.794951	7.02
		9.770127		60	9.584714		9.795372	

52°					53°		
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.
0	9.584714	4.32	9.795372	7.02	0	9.600085	4.22
1	.584973	4.32	.795793	7.00	1	.600338	4.22
2	.585232	4.32	.796213	7.02	2	.600591	4.23
3	.585491	4.30	.796634	7.02	3	.600845	4.22
4	.585749	4.32	.797055	7.02	4	.601098	4.22
5	9.586008	4.30	9.797476	7.00	5	9.601351	4.20
6	.586266	4.32	.797896	7.02	6	.601603	4.22
7	.586525	4.30	.798317	7.02	7	.601856	4.22
8	.586783	4.30	.798738	7.00	8	.602109	4.22
9	.587041	4.30	.799158	7.02	9	.602362	4.20
10	9.587299	4.30	9.799579	7.02	10	9.602614	4.20
11	.587557	4.30	.800000	7.02	11	.602866	4.22
12	.587815	4.30	.800421	7.00	12	.603119	4.20
13	.588073	4.30	.800841	7.02	13	.603371	4.20
14	.588331	4.28	.801262	7.02	14	.603623	4.20
15	9.588588	4.30	9.801683	7.02	15	9.603875	4.20
16	.588846	4.28	.802104	7.00	16	.604127	4.20
17	.589103	4.30	.802524	7.02	17	.604379	4.20
18	.589361	4.28	.802945	7.02	18	.604631	4.20
19	.589618	4.28	.803366	7.02	19	.604883	4.18
20	9.589875	4.28	9.803787	7.00	20	9.605134	4.20
21	.590132	4.28	.804207	7.02	21	.605386	4.18
22	.590389	4.28	.804628	7.02	22	.605637	4.18
23	.590646	4.28	.805049	7.02	23	.605888	4.20
24	.590903	4.28	.805470	7.02	24	.606140	4.18
25	9.591160	4.27	9.805891	7.00	25	9.606391	4.18
26	.591416	4.28	.806311	7.02	26	.606642	4.18
27	.591673	4.27	.806732	7.02	27	.606893	4.18
28	.591929	4.27	.807153	7.02	28	.607144	4.17
29	.592185	4.28	.807574	7.02	29	.607394	4.18
30	9.592442	4.27	9.807995	7.00	30	9.607645	4.18
31	.592698	4.27	.808415	7.02	31	.607896	4.17
32	.592954	4.27	.808836	7.02	32	.608146	4.18
33	.593210	4.27	.809257	7.02	33	.608397	4.17
34	.593466	4.25	.809678	7.02	34	.608647	4.17
35	9.593721	4.27	9.810099	7.02	35	9.608897	4.17
36	.593977	4.27	.810520	7.00	36	.609147	4.17
37	.594233	4.25	.810940	7.02	37	.609397	4.17
38	.594488	4.25	.811361	7.02	38	.609647	4.17
39	.594743	4.27	.811782	7.02	39	.609897	4.17
40	9.594999	4.25	9.812203	7.02	40	9.610147	4.17
41	.595254	4.25	.812624	7.02	41	.610397	4.15
42	.595509	4.25	.813045	7.02	42	.610646	4.17
43	.595764	4.25	.813466	7.00	43	.610896	4.15
44	.596019	4.25	.813886	7.02	44	.611145	4.15
45	9.596274	4.23	9.814307	7.02	45	9.611394	4.17
46	.596528	4.25	.814728	7.02	46	.611644	4.15
47	.596783	4.25	.815149	7.02	47	.611893	4.15
48	.597038	4.23	.815570	7.02	48	.612142	4.15
49	.597292	4.23	.815991	7.02	49	.612391	4.15
50	9.597546	4.25	9.816412	7.02	50	9.612640	4.13
51	.597801	4.23	.816833	7.02	51	.612888	4.15
52	.598055	4.23	.817254	7.02	52	.613137	4.15
53	.598309	4.23	.817675	7.02	53	.613386	4.13
54	.598563	4.23	.818096	7.02	54	.613634	4.15
55	9.598817	4.23	9.818517	7.02	55	9.613883	4.13
56	.599071	4.22	.818938	7.02	56	.614131	4.13
57	.599324	4.23	.819359	7.02	57	.614379	4.13
58	.599578	4.22	.819780	7.02	58	.614627	4.15
59	.599831	4.23	.820201	7.02	59	.614876	4.1
60	9.600085		9.820622		60	9.615124	

	54°			55°				
	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
	4.12	9.845905	7.03	0	9.629841	4.05	9.871250	7.05
	4.13	.846327	7.03	1	.630084	4.03	.871673	7.05
	4.13	.846749	7.02	2	.630326	4.05	.872096	7.05
	4.13	.847170	7.03	3	.630569	4.03	.872519	7.05
	4.12	.847592	7.03	4	.630811	4.05	.872942	7.07
	4.13	9.848014	7.03	5	9.631054	4.03	9.873366	7.05
	4.12	.848436	7.03	6	.631296	4.03	.873789	7.05
	4.12	.848858	7.03	7	.631538	4.03	.874212	7.07
	4.12	.849280	7.03	8	.631780	4.03	.874636	7.05
	4.12	.849702	7.03	9	.632022	4.03	.875059	7.05
	4.12	9.850124	7.03	10	9.632264	4.02	9.875482	7.07
	4.12	.850546	7.03	11	.632505	4.03	.875906	7.05
	4.12	.850968	7.03	12	.632747	4.03	.876329	7.05
	4.12	.851390	7.03	13	.632989	4.02	.876752	7.07
	4.12	.851812	7.03	14	.633230	4.03	.877176	7.05
	4.10	9.852234	7.03	15	9.633472	4.02	9.877599	7.07
	4.12	.852656	7.03	16	.633713	4.02	.878023	7.05
	4.10	.853078	7.03	17	.633954	4.02	.878446	7.07
	4.10	.853500	7.05	18	.634196	4.03	.878870	7.07
	4.12	.853923	7.03	19	.634437	4.02	.879294	7.05
	4.10	9.854345	7.03	20	9.634678	4.02	9.879717	7.07
	4.10	.854767	7.03	21	.634919	4.00	.880141	7.07
	4.10	.855189	7.05	22	.635159	4.02	.880565	7.07
	4.08	.855612	7.03	23	.635400	4.02	.880988	7.05
	4.10	.856034	7.03	24	.635641	4.00	.881412	7.07
	4.10	9.856456	7.03	25	9.635881	4.02	9.881836	7.07
	4.10	.856878	7.05	26	.636122	4.00	.882260	7.07
	4.08	.857301	7.03	27	.636362	4.02	.882683	7.05
	4.08	.857723	7.03	28	.636603	4.00	.883107	7.07
	4.10	.858145	7.05	29	.636843	4.00	.883531	7.07
	4.08	9.858568	7.03	30	9.637083	4.00	9.883955	7.07
	4.08	.858990	7.05	31	.637323	4.00	.884379	7.07
	4.08	.859413	7.03	32	.637563	4.00	.884803	7.07
	4.08	.859835	7.05	33	.637803	4.00	.885227	7.07
	4.08	.860258	7.03	34	.638043	4.00	.885651	7.07
	4.08	9.860680	7.05	35	9.638283	3.98	9.886075	7.07
	4.08	.861103	7.03	36	.638522	4.00	.886499	7.07
	4.07	.861525	7.05	37	.638762	3.98	.886923	7.07
	4.08	.861948	7.03	38	.639001	4.00	.887347	7.08
	4.07	.862370	7.05	39	.639241	3.98	.887772	7.07
	4.08	9.862793	7.03	40	9.639480	3.98	9.888196	7.07
	4.07	.863215	7.05	41	.639719	3.98	.888620	7.07
	4.07	.863638	7.05	42	.639958	3.98	.889044	7.08
	4.07	.864061	7.03	43	.640197	3.98	.889469	7.07
	4.07	.864483	7.05	44	.640436	3.98	.889893	7.07
	4.07	9.864906	7.05	45	9.640675	3.98	9.890317	7.08
	4.07	.865329	7.05	46	.640914	3.98	.890742	7.07
	4.07	.865752	7.03	47	.641153	3.97	.891166	7.08
	4.05	.866174	7.05	48	.641391	3.98	.891591	7.07
	4.07	.866597	7.05	49	.641630	3.97	.892015	7.08
	4.07	9.867020	7.05	50	9.641868	3.98	9.892440	7.07
	4.05	.867443	7.05	51	.642107	3.97	.892864	7.08
	4.05	.867866	7.05	52	.642345	3.97	.893289	7.08
	4.05	.868289	7.05	53	.642583	3.97	.893714	7.07
	4.07	.868712	7.05	54	.642822	3.98	.894138	7.08
	4.05	9.869135	7.05	55	9.643060	3.97	9.894563	7.08
	4.05	.869558	7.05	56	.643298	3.97	.894988	7.08
	4.05	.869981	7.05	57	.643535	3.95	.895412	7.07
	4.05	.870404	7.05	58	.643773	3.97	.895837	7.08
	4.03	.870827	7.05	59	.644011	3.97	.896262	7.08
	4.05	9.871250	7.05	60	9.644249	3.97	9.896687	7.08

56°					57°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	
0	9.644249	3.95	9.896687	7.08	0	9.658356	3.87	
1	.644486	3.97	.897112	7.08	1	.658588	3.88	
2	.644724	3.95	.897537	7.08	2	.658821	3.87	
3	.644961	3.95	.897962	7.08	3	.659053	3.88	
4	.645198	3.97	.898387	7.08	4	.659286	3.87	
5	9.645436	3.95	9.898812	7.08	5	9.659518	3.87	
6	.645673	3.95	.899237	7.08	6	.659750	3.88	
7	.645910	3.95	.899662	7.08	7	.659983	3.87	
8	.646147	3.95	.900087	7.08	8	.660215	3.87	
9	.646384	3.93	.900512	7.10	9	.660447	3.87	
10	9.646620	3.95	9.900938	7.08	10	9.660679	3.85	
11	.646857	3.95	.901363	7.08	11	.660910	3.87	
12	.647094	3.93	.901788	7.08	12	.661142	3.87	
13	.647330	3.95	.902213	7.10	13	.661374	3.85	
14	.647567	3.93	.902639	7.08	14	.661605	3.87	
15	9.647803	3.93	9.903064	7.10	15	9.661837	3.85	
16	.648039	3.95	.903490	7.08	16	.662068	3.87	
17	.648276	3.93	.903915	7.10	17	.662300	3.85	
18	.648512	3.93	.904341	7.08	18	.662531	3.85	
19	.648748	3.93	.904766	7.10	19	.662762	3.85	
20	9.648984	3.93	9.905192	7.08	20	9.662993	3.85	
21	.649220	3.93	.905617	7.10	21	.663224	3.85	
22	.649456	3.92	.906043	7.10	22	.663455	3.85	
23	.649691	3.93	.906469	7.08	23	.663686	3.85	
24	.649927	3.93	.906894	7.10	24	.663917	3.85	
25	9.650163	3.92	9.907320	7.10	25	9.664148	3.83	
26	.650398	3.92	.907746	7.10	26	.664378	3.85	
27	.650633	3.93	.908172	7.10	27	.664609	3.83	
28	.650869	3.92	.908598	7.10	28	.664839	3.85	
29	.651104	3.92	.909024	7.10	29	.665070	3.83	
30	9.651339	3.92	9.909450	7.10	30	9.665300	3.83	
31	.651574	3.92	.909876	7.10	31	.665530	3.83	
32	.651809	3.92	.910302	7.10	32	.665760	3.83	
33	.652044	3.92	.910728	7.10	33	.665990	3.83	
34	.652279	3.92	.911154	7.10	34	.666220	3.83	
35	9.652514	3.90	9.911580	7.10	35	9.666450	3.83	
36	.652748	3.92	.912006	7.10	36	.666680	3.83	
37	.652983	3.90	.912432	7.12	37	.666910	3.82	
38	.653217	3.92	.912859	7.10	38	.667139	3.83	
39	.653452	3.90	.913285	7.10	39	.667369	3.83	
40	9.653686	3.90	9.913711	7.12	40	9.667599	3.82	
41	.653920	3.92	.914138	7.10	41	.667828	3.82	
42	.654155	3.90	.914564	7.12	42	.668057	3.83	
43	.654389	3.90	.914991	7.10	43	.668287	3.82	
44	.654623	3.90	.915417	7.12	44	.668516	3.82	
45	9.654857	3.88	9.915844	7.10	45	9.668745	3.82	
46	.655090	3.90	.916270	7.12	46	.668974	3.82	
47	.655324	3.90	.916697	7.12	47	.669203	3.82	
48	.655558	3.90	.917124	7.10	48	.669432	3.82	
49	.655792	3.88	.917550	7.12	49	.669661	3.80	
50	9.656025	3.88	9.917977	7.12	50	9.669889	3.82	
51	.656258	3.90	.918404	7.12	51	.670118	3.82	
52	.656492	3.88	.918831	7.12	52	.670347	3.80	
53	.656725	3.88	.919258	7.12	53	.670575	3.82	
54	.656958	3.88	.919685	7.12	54	.670804	3.80	
55	9.657191	3.88	9.920112	7.12	55	9.671032	3.80	
56	.657424	3.88	.920539	7.12	56	.671260	3.80	
57	.657657	3.88	.920966	7.12	57	.671488	3.80	
58	.657890	3.88	.921393	7.12	58	.671716	3.82	
59	.658123	3.88	.921820	7.12	59	.671945	3.78	
60	9.658356		9.922247		60	9.672172		

58°			59°				
D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
	9.947963		0	9.685708		9.973868	
3.80	.948393	7.17	1	.685931	3.72	.974302	7.23
3.80	.948823	7.17	2	.686154	3.72	.974736	7.23
3.80	.949253	7.17	3	.686377	3.72	.975169	7.22
3.78	.949683	7.17	4	.686600	3.72	.975603	7.23
3.80	9.950114	7.18	5	9.686823	3.72	9.976037	7.23
3.78	.950544	7.17	6	.687046	3.72	.976471	7.23
3.80	.950975	7.18	7	.687269	3.72	.976905	7.23
3.78	.951405	7.17	8	.687492	3.72	.977339	7.23
3.78	.951836	7.18	9	.687714	3.70	.977773	7.23
3.80		7.17			3.72		7.23
	9.952266		10	9.687937		9.978207	
3.78	.952697	7.18	11	.688159	3.70	.978641	7.23
3.78	.953128	7.18	12	.688382	3.72	.979075	7.23
3.78	.953558	7.17	13	.688604	3.70	.979510	7.25
3.78	.953989	7.18	14	.688826	3.70	.979944	7.23
3.77	9.954420	7.18	15	9.689048	3.70	9.980379	7.25
3.78	.954851	7.18	16	.689271	3.72	.980813	7.23
3.78	.955282	7.18	17	.689493	3.70	.981248	7.25
3.77	.955713	7.18	18	.689715	3.70	.981682	7.23
3.78	.956144	7.18	19	.689937	3.70	.982117	7.25
3.77					3.68		7.25
	9.956575	7.18	20	9.690158	3.70	9.982552	7.25
3.77	.957006	7.20	21	.690380	3.70	.982987	7.25
3.78	.957438	7.18	22	.690602	3.68	.983422	7.25
3.77	.957869	7.18	23	.690823	3.70	.983857	7.25
3.77	.958300	7.20	24	.691045	3.68	.984292	7.25
3.77	9.958732	7.18	25	9.691266	3.70	9.984727	7.25
3.77	.959163	7.20	26	.691488	3.68	.985162	7.25
3.77	.959595	7.18	27	.691709	3.68	.985597	7.27
3.75	.960026	7.20	28	.691930	3.68	.986033	7.25
3.77	.960458	7.20	29	.692151	3.68	.986468	7.27
3.77					3.68		7.27
	9.960890	7.18	30	9.692372	3.68	9.986904	7.25
3.75	.961321	7.20	31	.692593	3.68	.987339	7.27
3.77	.961753	7.20	32	.692814	3.68	.987775	7.25
3.75	.962185	7.20	33	.693035	3.68	.988210	7.27
3.75	.962617	7.20	34	.693256	3.68	.988646	7.27
3.77	9.963049	7.20	35	9.693477	3.67	9.989082	7.27
3.75	.963481	7.20	36	.693697	3.68	.989518	7.27
3.75	.963913	7.20	37	.693918	3.67	.989954	7.27
3.75	.964345	7.22	38	.694138	3.68	.990390	7.27
3.75	.964778	7.20	39	.694359	3.67	.990826	7.27
	9.965210		40	9.694579		9.991262	
3.73	.965642	7.20	41	.694799	3.67	.991698	7.27
3.75	.966075	7.22	42	.695019	3.67	.992134	7.27
3.75	.966507	7.20	43	.695240	3.68	.992571	7.28
3.73	.966940	7.22	44	.695460	3.67	.993007	7.27
3.75	9.967372	7.20	45	9.695680	3.67	9.993444	7.28
3.73	.967805	7.22	46	.695899	3.65	.993880	7.27
3.73	.968238	7.22	47	.696119	3.67	.994317	7.28
3.75	.968670	7.20	48	.696339	3.67	.994754	7.28
3.73	.969103	7.22	49	.696559	3.67	.995191	7.28
3.73		7.22			3.65		7.27
	9.969536		50	9.696778		9.995627	
3.73	.969969	7.22	51	.696998	3.67	.996064	7.28
3.73	.970402	7.22	52	.697217	3.65	.996501	7.28
3.73	.970835	7.22	53	.697437	3.67	.996938	7.28
3.73	.971268	7.22	54	.697656	3.65	.997376	7.30
3.72	9.971701	7.22	55	9.697875	3.65	9.997813	7.28
3.73	.972135	7.23	56	.698094	3.65	.998250	7.28
3.72	.972568	7.22	57	.698313	3.65	.998687	7.30
3.73	.973001	7.22	58	.698532	3.65	.999125	7.28
3.72	.973435	7.23	59	.698751	3.65	.999562	
3.73	9.973868	7.22	60	9.698970	3.65	0.000000	

64°					65°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	
0	9.749449	3.38	0.107607	7.70	0	9.761463	3.30	0
1	.749652	3.37	.108069	7.68	1	.761661	3.32	
2	.749854	3.37	.108530	7.70	2	.761860	3.30	
3	.750056	3.37	.108992	7.68	3	.762058	3.30	
4	.750258	3.35	.109453	7.70	4	.762256	3.30	
5	9.750459	3.37	0.109915	7.70	5	9.762454	3.30	0
6	.750661	3.37	.110377	7.70	6	.762652	3.30	
7	.750863	3.37	.110839	7.70	7	.762850	3.28	
8	.751065	3.35	.111301	7.70	8	.763047	3.30	
9	.751266	3.37	.111763	7.72	9	.763245	3.30	
10	9.751468	3.35	0.112226	7.70	10	9.763443	3.30	0
11	.751669	3.37	.112688	7.72	11	.763641	3.28	
12	.751871	3.35	.113151	7.72	12	.763838	3.30	
13	.752072	3.35	.113614	7.72	13	.764036	3.28	
14	.752273	3.37	.114077	7.72	14	.764233	3.28	
15	9.752475	3.35	0.114540	7.72	15	9.764430	3.30	0
16	.752676	3.35	.115003	7.72	16	.764628	3.28	
17	.752877	3.35	.115466	7.72	17	.764825	3.28	
18	.753078	3.35	.115929	7.73	18	.765022	3.28	
19	.753279	3.35	.116393	7.73	19	.765219	3.28	
20	9.753480	3.35	0.116857	7.73	20	9.765416	3.28	0
21	.753681	3.33	.117321	7.73	21	.765613	3.28	
22	.753881	3.35	.117785	7.73	22	.765810	3.28	
23	.754082	3.35	.118249	7.73	23	.766007	3.28	
24	.754283	3.33	.118713	7.73	24	.766204	3.28	
25	9.754483	3.35	0.119177	7.75	25	9.766401	3.27	0
26	.754684	3.33	.119642	7.73	26	.766597	3.28	
27	.754884	3.35	.120106	7.75	27	.766794	3.28	
28	.755085	3.33	.120571	7.75	28	.766991	3.27	
29	.755285	3.33	.121036	7.75	29	.767187	3.28	
30	9.755485	3.33	0.121501	7.75	30	9.767384	3.27	0
31	.755685	3.35	.121966	7.75	31	.767580	3.27	
32	.755886	3.33	.122431	7.77	32	.767776	3.27	
33	.756086	3.33	.122897	7.75	33	.767972	3.28	
34	.756286	3.33	.123362	7.77	34	.768169	3.27	
35	9.756486	3.32	0.123828	7.77	35	9.768365	3.27	0
36	.756685	3.33	.124294	7.77	36	.768561	3.27	
37	.756885	3.33	.124760	7.77	37	.768757	3.27	
38	.757085	3.33	.125226	7.77	38	.768953	3.27	
39	.757285	3.32	.125692	7.77	39	.769149	3.25	
40	9.757484	3.33	0.126158	7.78	40	9.769344	3.27	0
41	.757684	3.32	.126625	7.78	41	.769540	3.27	
42	.757883	3.33	.127092	7.77	42	.769736	3.25	
43	.758083	3.32	.127558	7.78	43	.769931	3.27	
44	.758282	3.32	.128025	7.78	44	.770127	3.27	
45	9.758481	3.33	0.128492	7.80	45	9.770323	3.25	0
46	.758681	3.32	.128960	7.78	46	.770518	3.25	
47	.758880	3.32	.129427	7.78	47	.770713	3.27	
48	.759079	3.32	.129894	7.80	48	.770909	3.25	
49	.759278	3.32	.130362	7.80	49	.771104	3.25	
50	9.759477	3.32	0.130830	7.80	50	9.771299	3.25	0
51	.759676	3.32	.131298	7.80	51	.771494	3.25	
52	.759875	3.30	.131766	7.80	52	.771689	3.25	
53	.760073	3.32	.132234	7.80	53	.771884	3.25	
54	.760272	3.32	.132702	7.80	54	.772079	3.25	
55	9.760471	3.30	0.133170	7.82	55	9.772274	3.25	0
56	.760669	3.32	.133639	7.82	56	.772469	3.25	
57	.760868	3.30	.134108	7.82	57	.772664	3.25	
58	.761066	3.32	.134577	7.82	58	.772858	3.25	
59	.761265	3.30	.135046	7.82	59	.773053	3.25	
60	9.761463		0.135515		60	9.773248		

62°				63°				
	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.	D. 1″.
9		0.053099		0	9.737200		0.080153	
9	3.50	.053547	7.47	1	.737406	3.43	.080608	7.58
9	3.50	.053995	7.47	2	.737612	3.43	.081062	7.57
9	3.50	.054443	7.47	3	.737818	3.43	.081516	7.57
9	3.50	.054892	7.48	4	.738024	3.43	.081971	7.58
9	3.50	0.055340	7.47	5	9.738230	3.43	0.082425	7.57
9	3.50	.055788	7.47	6	.738436	3.43	.082880	7.58
9	3.50	.056237	7.48	7	.738642	3.43	.083335	7.58
8	3.48	.056685	7.47	8	.738847	3.42	.083790	7.58
8	3.50	.057134	7.48	9	.739053	3.43	.084245	7.58
8	3.50		7.48			3.42		7.58
		0.057583		10	9.739258		0.084700	
7	3.48	.058032	7.48	11	.739464	3.43	.085155	7.58
7	3.50	.058481	7.48	12	.739669	3.42	.085611	7.60
6	3.48	.058930	7.48	13	.739875	3.43	.086066	7.58
5	3.48	.059379	7.48	14	.740080	3.42	.086522	7.60
5	3.50	0.059828	7.50	15	9.740285	3.42	0.086977	7.58
4	3.48	.060278	7.50	16	.740490	3.42	.087433	7.60
3	3.48	.060727	7.48	17	.740695	3.42	.087889	7.60
2	3.48	.061177	7.50	18	.740900	3.42	.088345	7.60
1	3.48	.061626	7.48	19	.741105	3.42	.088801	7.60
			7.50			3.42		7.62
0		0.062076		20	9.741310		0.089258	
9	3.48	.062526	7.50	21	.741515	3.42	.089714	7.60
7	3.47	.062976	7.50	22	.741719	3.40	.090171	7.62
6	3.48	.063426	7.50	23	.741924	3.42	.090627	7.60
5	3.48	.063876	7.50	24	.742129	3.42	.091084	7.62
3	3.47	0.064327	7.52	25	9.742333	3.40	0.091541	7.62
2	3.48	.064777	7.50	26	.742538	3.42	.091998	7.62
0	3.47	.065227	7.50	27	.742742	3.40	.092455	7.62
9	3.48	.065678	7.52	28	.742946	3.40	.092912	7.62
7	3.47	.066129	7.52	29	.743150	3.40	.093370	7.63
	3.47		7.52			3.42		7.62
5		0.066580		30	9.743355		0.093827	
3	3.47	.067030	7.50	31	.743559	3.40	.094285	7.63
1	3.47	.067482	7.53	32	.743763	3.40	.094743	7.63
9	3.47	.067933	7.52	33	.743967	3.40	.095200	7.62
7	3.47	.068384	7.52	34	.744171	3.40	.095658•	7.63
5	3.47	0.068835	7.52	35	9.744375	3.40	0.096116	7.63
3	3.47	.069287	7.53	36	.744578	3.38	.096575	7.65
1	3.47	.069738	7.52	37	.744782	3.40	.097033	7.63
8	3.45	.070190	7.53	38	.744986	3.40	.097491	7.63
6	3.47	.070642	7.53	39	.745189	3.38	.097950	7.65
	3.47		7.52			3.40		7.63
4		0.071093		40	9.745393		0.098408	
1	3.45	.071545	7.53	41	.745596	3.38	.098867	7.65
8	3.45	.071998	7.55	42	.745800	3.40	.099326	7.65
6	3.47	.072450	7.53	43	.746003	3.38	.099785	7.65
3	3.45	.072902	7.53	44	.746206	3.38	.100244	7.65
1	3.45	0.073354	7.53	45	9.746409	3.38	0.100704	7.67
7	3.45	.073807	7.55	46	.746613	3.40	.101163	7.65
5	3.47	.074260	7.55	47	.746816	3.38	.101623	7.67
1	3.43	.074712	7.53	48	.747019	3.38	.102082	7.65
8	3.45	.075165	7.55	49	.747222	3.38	.102542	7.67
	3.45		7.55			3.37		7.67
5		0.075618		50	9.747424		0.103002	
2	3.45	.076071	7.55	51	.747627	3.38	.103462	7.67
9	3.45	.076524	7.55	52	.747830	3.38	.103922	7.67
5	3.43	.076977	7.55	53	.748033	3.38	.104382	7.67
2	3.45	.077431	7.57	54	.748235	3.37	.104843	7.68
9	3.45	0.077884	7.55	55	9.748438	3.38	0.105303	7.67
5	3.43	.078338	7.57	56	.748640	3.37	.105764	7.68
2	3.43	.078792	7.57	57	.748843	3.38	.106224	7.67
8	3.45	.079245	7.55	58	.749045	3.37	.106685	7.68
4	3.43	.079699	7.57	59	.749247	3.37	.107146	7.68
0	3.43	0.080153	7.57	60	9.749449	3.37	0.107607	7.68

64°					65°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.
0	9.749449	3.38	0.107607	7.70	0	9.761463	3.30	0.135515
1	.749652	3.37	.108069	7.68	1	.761661	3.32	.135984
2	.749854	3.37	.108530	7.70	2	.761860	3.30	.136454
3	.750056	3.37	.108992	7.68	3	.762058	3.30	.136923
4	.750258	3.35	.109453	7.70	4	.762256	3.30	.137393
5	9.750459	3.37	0.109915	7.70	5	9.762454	3.30	0.137863
6	.750661	3.37	.110377	7.70	6	.762652	3.30	.138333
7	.750863	3.37	.110839	7.70	7	.762850	3.30	.138803
8	.751065	3.35	.111301	7.70	8	.763047	3.28	.139273
9	.751266	3.37	.111763	7.72	9	.763245	3.30	.139744
10	9.751468	3.35	0.112226	7.70	10	9.763443	3.30	0.140214
11	.751669	3.37	.112688	7.72	11	.763641	3.28	.140685
12	.751871	3.35	.113151	7.72	12	.763838	3.30	.141156
13	.752072	3.35	.113614	7.72	13	.764036	3.28	.141627
14	.752273	3.35	.114077	7.72	14	.764233	3.28	.142098
15	9.752475	3.37	0.114540	7.72	15	9.764430	3.28	0.142569
16	.752676	3.35	.115003	7.72	16	.764628	3.30	.143041
17	.752877	3.35	.115466	7.72	17	.764825	3.28	.143512
18	.753078	3.35	.115929	7.72	18	.765022	3.28	.143984
19	.753279	3.35	.116393	7.73	19	.765219	3.28	.144456
20	9.753480	3.35	0.116857	7.73	20	9.765416	3.28	0.144928
21	.753681	3.33	.117321	7.73	21	.765613	3.28	.145400
22	.753881	3.35	.117785	7.73	22	.765810	3.28	.145872
23	.754082	3.35	.118249	7.73	23	.766007	3.28	.146345
24	.754283	3.35	.118713	7.73	24	.766204	3.28	.146818
25	9.754483	3.33	0.119177	7.73	25	9.766401	3.28	0.147290
26	.754684	3.35	.119642	7.75	26	.766597	3.27	.147763
27	.754884	3.33	.120106	7.73	27	.766794	3.28	.148236
28	.755085	3.35	.120571	7.75	28	.766991	3.28	.148710
29	.755285	3.33	.121036	7.75	29	.767187	3.27	.149183
30	9.755485	3.33	0.121501	7.75	30	9.767384	3.28	0.149657
31	.755685	3.35	.121966	7.75	31	.767580	3.27	.150130
32	.755886	3.33	.122431	7.77	32	.767776	3.27	.150604
33	.756086	3.33	.122897	7.75	33	.767972	3.27	.151078
34	.756286	3.33	.123362	7.77	34	.768169	3.28	.151552
35	9.756486	3.33	0.123828	7.77	35	9.768365	3.27	0.152027
36	.756685	3.32	.124294	7.77	36	.768561	3.27	.152501
37	.756885	3.33	.124760	7.77	37	.768757	3.27	.152976
38	.757085	3.33	.125226	7.77	38	.768953	3.27	.153450
39	.757285	3.33	.125692	7.77	39	.769149	3.25	.153925
40	9.757484	3.33	0.126158	7.78	40	9.769344	3.27	0.154400
41	.757684	3.32	.126625	7.78	41	.769540	3.27	.154876
42	.757883	3.33	.127092	7.77	42	.769736	3.25	.155351
43	.758083	3.32	.127558	7.78	43	.769931	3.27	.155826
44	.758282	3.32	.128025	7.78	44	.770127	3.27	.156302
45	9.758481	3.33	0.128492	7.80	45	9.770323	3.27	0.156778
46	.758681	3.32	.128960	7.78	46	.770518	3.25	.157254
47	.758880	3.32	.129427	7.78	47	.770713	3.25	.157730
48	.759079	3.32	.129894	7.80	48	.770909	3.27	.158206
49	.759278	3.32	.130362	7.80	49	.771104	3.25	.158683
50	9.759477	3.32	0.130830	7.80	50	9.771299	3.25	0.159159
51	.759676	3.32	.131298	7.80	51	.771494	3.25	.159636
52	.759875	3.30	.131766	7.80	52	.771689	3.25	.160113
53	.760073	3.32	.132234	7.80	53	.771884	3.25	.160590
54	.760272	3.32	.132702	7.80	54	.772079	3.25	.161067
55	9.760471	3.32	0.133170	7.82	55	9.772274	3.25	0.161545
56	.760669	3.30	.133639	7.82	56	.772469	3.25	.162022
57	.760868	3.32	.134108	7.82	57	.772664	3.25	.162500
58	.761066	3.30	.134577	7.82	58	.772858	3.23	.162978
59	.761265	3.32	.135046	7.82	59	.773053	3.25	.163456
60	9.761463	3.30	0.135515	7.82	60	9.773248	3.25	0.163934

0°			1°			2°			
S.	Vers.	Exsec.	S.	Vers.	Exsec.	S.	Vers.	Exsec.	M.
	9.07			9.07			9.07		
0	0120	0120	3600	0109	0175	7200	0076	0340	0
60	0120	0120	3660	0108	0177	7260	0075	0344	1
120	0120	0120	3720	0108	0179	7320	0074	0348	2
180	0120	0120	3780	0108	0181	7380	0073	0351	3
240	0120	0120	3840	0107	0182	7440	0073	0355	4
300	0120	0120	3900	0107	0184	7500	0072	0359	5
360	0120	0120	3960	0106	0186	7560	0071	0363	6
420	0120	0120	4020	0106	0188	7620	0070	0367	7
480	0120	0121	4080	0106	0191	7680	0070	0371	8
540	0119	0121	4140	0105	0193	7740	0069	0375	9
600	0119	0121	4200	0105	0195	7800	0068	0379	10
660	0119	0122	4260	0104	0197	7860	0067	0383	11
720	0119	0122	4320	0104	0199	7920	0066	0387	12
780	0119	0122	4380	0103	0201	7980	0066	0391	13
840	0119	0123	4440	0103	0204	8040	0065	0395	14
900	0119	0123	4500	0103	0206	8100	0064	0399	15
960	0119	0124	4560	0102	0208	8160	0063	0403	16
1020	0119	0124	4620	0102	0211	8220	0062	0407	17
1080	0119	0125	4680	0101	0213	8280	0061	0411	18
1140	0119	0125	4740	0101	0215	8340	0061	0416	19
1200	0119	0126	4800	0100	0218	8400	0060	0420	20
1260	0118	0126	4860	0100	0220	8460	0059	0424	21
1320	0118	0127	4920	0099	0223	8520	0058	0429	22
1380	0118	0128	4980	0099	0225	8580	0057	0433	23
1440	0118	0129	5040	0098	0228	8640	0056	0437	24
1500	0118	0129	5100	0098	0230	8700	0055	0442	25
1560	0118	0130	5160	0097	0233	8760	0054	0446	26
1620	0118	0131	5220	0097	0236	8820	0054	0451	27
1680	0117	0132	5280	0096	0238	8880	0053	0455	28
1740	0117	0133	5340	0095	0241	8940	0052	0460	29
1800	0117	0134	5400	0095	0244	9000	0051	0464	30
1860	0117	0134	5460	0094	0247	9060	0050	0469	31
1920	0117	0135	5520	0094	0249	9120	0049	0474	32
1980	0116	0136	5580	0093	0252	9180	0048	0478	33
2040	0116	0137	5640	0093	0255	9240	0047	0483	34
2100	0116	0138	5700	0092	0258	9300	0046	0488	35
2160	0116	0140	5760	0092	0261	9360	0045	0493	36
2220	0116	0141	5820	0091	0264	9420	0044	0497	37
2280	0115	0142	5880	0090	0267	9480	0043	0502	38
2340	0115	0143	5940	0090	0270	9540	0042	0507	39
2400	0115	0144	6000	0089	0273	9600	0041	0512	40
2460	0115	0145	6060	0088	0276	9660	0040	0517	41
2520	0114	0147	6120	0088	0279	9720	0039	0522	42
2580	0114	0148	6180	0087	0282	9780	0038	0527	43
2640	0114	0149	6240	0087	0285	9840	0037	0532	44
2700	0114	0151	6300	0086	0289	9900	0036	0537	45
2760	0113	0152	6360	0085	0292	9960	0035	0542	46
2820	0113	0154	6420	0085	0295	10020	0034	0547	47
2880	0113	0155	6480	0084	0298	10080	0033	0552	48
2940	0112	0157	6540	0083	0302	10140	0032	0557	49
3000	0112	0158	6600	0083	0305	10200	0031	0562	50
3060	0112	0160	6660	0082	0308	10260	0030	0568	51
3120	0111	0161	6720	0081	0312	10320	0029	0573	52
3180	0111	0163	6780	0081	0315	10380	0028	0578	53
3240	0111	0164	6840	0080	0319	10440	0027	0584	54
3300	0110	0166	6900	0079	0322	10500	0026	0589	55
3360	0110	0168	6960	0079	0326	10560	0025	0594	56
3420	0110	0169	7020	0078	0329	10620	0024	0600	57
3480	0109	0171	7080	0077	0333	10680	0023	0605	58
3540	0109	0173	7140	0076	0337	10740	0022	0611	59
S.	Vers.	Exsec.	S.	Vers.	Exsec.	S.	Vers.	Exsec.	M.

72°					73°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Ex
0	9.839467	2.90	0.349485	9.38	0	9.849805	2.85	0.3
1	.839641	2.90	.350048	9.38	1	.849976	2.85	.3
2	.839815	2.90	.350611	9.40	2	.850147	2.83	.3
3	.839989	2.88	.351175	9.38	3	.850317	2.85	.3
4	.840162	2.90	.351738	9.42	4	.850488	2.83	.3
5	9.840336	2.90	0.352303	9.40	5	9.850658	2.85	0.3
6	.840510	2.88	.352867	9.42	6	.850829	2.83	.3
7	.840683	2.90	.353432	9.42	7	.850999	2.83	.3
8	.840857	2.88	.353997	9.43	8	.851169	2.85	.3
9	.841030	2.90	.354563	9.43	9	.851340	2.83	.3
10	9.841204	2.88	0.355129	9.43	10	9.851510	2.83	0.3
11	.841377	2.88	.355695	9.43	11	.851680	2.83	.3
12	.841550	2.88	.356261	9.45	12	.851850	2.83	.3
13	.841723	2.88	.356828	9.45	13	.852020	2.83	.3
14	.841896	2.90	.357395	9.47	14	.852190	2.83	.3
15	9.842070	2.88	0.357963	9.47	15	9.852360	2.83	0.3
16	.842243	2.88	.358531	9.47	16	.852530	2.83	.3
17	.842416	2.88	.359099	9.48	17	.852700	2.83	.3
18	.842589	2.88	.359668	9.48	18	.852870	2.83	.3
19	.842762	2.87	.360237	9.48	19	.853040	2.82	.3
20	9.842934	2.88	0.360806	9.50	20	9.853209	2.83	0.3
21	.843107	2.88	.361376	9.50	21	.853379	2.83	.3
22	.843280	2.88	.361946	9.50	22	.853549	2.82	.3
23	.843453	2.87	.362516	9.52	23	.853718	2.83	.3
24	.843625	2.88	.363087	9.52	24	.853888	2.82	.3
25	9.843798	2.87	0.363658	9.52	25	9.854057	2.83	0.3
26	.843970	2.88	.364229	9.53	26	.854227	2.82	.3
27	.844143	2.87	.364801	9.53	27	.854396	2.82	.3
28	.844315	2.88	.365373	9.53	28	.854565	2.83	.4
29	.844488	2.87	.365945	9.55	29	.854735	2.82	.4
30	9.844660	2.87	0.366518	9.55	30	9.854904	2.82	0.4
31	.844832	2.87	.367091	9.57	31	.855073	2.82	.4
32	.845004	2.88	.367665	9.57	32	.855242	2.82	.4
33	.845177	2.87	.368239	9.57	33	.855411	2.82	.4
34	.845349	2.87	.368813	9.57	34	.855580	2.82	.4
35	9.845521	2.87	0.369387	9.58	35	9.855749	2.82	0.4
36	.845693	2.87	.369962	9.60	36	.855918	2.82	.4
37	.845865	2.87	.370538	9.58	37	.856087	2.80	.4
38	.846037	2.85	.371113	9.60	38	.856255	2.82	.4
39	.846208	2.87	.371689	9.62	39	.856424	2.82	.4
40	9.846380	2.87	0.372266	9.60	40	9.856593	2.82	0.4
41	.846552	2.87	.372842	9.62	41	.856762	2.80	.4
42	.846724	2.85	.373419	9.63	42	.856930	2.82	.4
43	.846895	2.87	.373997	9.63	43	.857099	2.80	.4
44	.847067	2.85	.374575	9.63	44	.857267	2.82	.4
45	9.847238	2.87	0.375153	9.63	45	9.857436	2.80	0.4
46	.847410	2.85	.375731	9.65	46	.857604	2.80	.4
47	.847581	2.87	.376310	9.67	47	.857772	2.82	.4
48	.847753	2.85	.376890	9.65	48	.857941	2.80	.4
49	.847924	2.85	.377469	9.67	49	.858109	2.80	.4
50	9.848095	2.87	0.378049	9.68	50	9.858277	2.80	0.4
51	.848267	2.85	.378630	9.67	51	.858445	2.80	.4
52	.848438	2.85	.379210	9.70	52	.858613	2.80	.4
53	.848609	2.85	.379792	9.68	53	.858781	2.80	.4
54	.848780	2.85	.380373	9.70	54	.858949	2.80	.4
55	9.848951	2.85	0.380955	9.70	55	9.859117	2.80	0.4
56	.849122	2.85	.381537	9.72	56	.859285	2.80	.4
57	.849293	2.85	.382120	9.72	57	.859453	2.80	.4
58	.849464	2.83	.382703	9.72	58	.859621	2.78	.4
59	.849634	2.85	.383286	9.73	59	.859788	2.80	.4
60	9.849805		0.383870		60	9.859956		0.4

10°		11°		12°		13°		14°		
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
5	.98481	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	60
3	476	109	157	820	809	523	430	220	023	59
2	471	138	152	848	803	552	424	249	015	58
1	466	167	146	877	797	580	417	277	008	57
0	461	195	140	905	791	608	411	305	001	56
5	.98455	.19224	.98135	.20933	.97784	.22637	.97404	.24333	.96994	55
7	450	252	129	962	778	665	398	362	987	54
3	445	281	124	990	772	693	391	390	980	53
1	440	309	118	.21019	766	722	384	418	973	52
0	435	338	112	047	760	750	378	446	966	51
1	.98430	.19366	.98107	.21076	.97754	.22778	.97371	.24474	.96959	50
0	425	395	101	104	748	807	365	503	952	49
8	420	423	096	132	742	835	358	531	945	48
7	414	452	090	161	735	863	351	559	937	47
6	409	481	084	189	729	892	345	587	930	46
5	.98404	.19509	.98079	.21218	.97723	.22920	.97338	.24615	.96923	45
4	399	538	073	246	717	948	331	644	916	44
3	394	566	067	275	711	977	325	672	909	43
2	389	595	061	303	705	.23005	318	700	902	42
1	383	623	056	331	698	033	311	728	894	41
0	.98378	.19652	.98050	.21360	.97692	.23062	.97304	.24756	.96887	40
9	373	680	044	388	686	090	298	784	880	39
8	368	709	039	417	680	118	291	813	873	38
7	362	737	033	445	673	146	284	841	866	37
6	357	766	027	474	667	175	278	869	858	36
5	.98352	.19794	.98021	.21502	.97661	.23203	.97271	.24897	.96851	35
4	347	823	016	530	655	231	264	925	844	34
3	341	851	010	559	648	260	257	954	837	33
2	336	880	004	587	642	288	251	982	829	32
1	331	908	.97998	616	636	316	244	.25010	822	31
0	.98325	.19937	.97992	.21644	.97630	.23345	.97237	.25038	.96815	30
9	320	965	987	672	623	373	230	066	807	29
8	315	994	981	701	617	401	223	094	800	28
7	310	.20022	975	729	611	429	217	122	793	27
6	304	051	969	758	604	458	210	151	786	26
5	.98299	.20079	.97963	.21786	.97598	.23486	.97203	.25179	.96778	25
4	294	108	958	814	592	514	196	207	771	24
3	288	136	952	843	585	542	189	235	764	23
2	283	165	946	871	579	571	182	263	756	22
1	277	193	940	899	573	599	176	291	749	21
0	.98272	.20222	.97934	.21928	.97566	.23627	.97169	.25320	.96742	20
9	267	250	928	956	560	656	162	348	734	19
8	261	279	922	985	553	684	155	376	727	18
7	256	307	916	.22013	547	712	148	404	719	17
6	250	336	910	041	541	740	141	432	712	16
5	.98245	.20364	.97905	.22070	.97534	.23769	.97134	.25460	.96705	15
4	240	393	899	098	528	797	127	488	697	14
3	234	421	893	126	521	825	120	516	690	13
2	229	450	887	155	515	853	113	545	682	12
1	223	478	881	183	508	882	106	573	675	11
0	.98218	.20507	.97875	.22212	.97502	.23910	.97100	.25601	.96667	10
9	212	535	869	240	496	938	093	629	660	9
8	207	563	863	268	489	966	086	657	653	8
7	201	592	857	297	483	995	079	685	645	7
6	196	620	851	325	476	.24023	072	713	638	6
5	.98190	.20649	.97845	.22353	.97470	.24051	.97065	.25741	.96630	5
4	185	677	839	382	463	079	058	769	623	4
3	179	706	833	410	457	108	051	798	615	3
2	174	734	827	438	450	136	044	826	608	2
1	168	763	821	467	444	164	037	854	600	1
0	.98163	.20791	.97815	.22495	.97437	.24192	.97030	.25882	.96593	0
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
	78°		77°		76°		75°			

76°					77°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Ex
0	9.879714	2.70	0.496039	11.13	0	9.889329	2.65	0.5
1	.879876	2.68	.496707	11.17	1	.889488	2.65	.5
2	.880037	2.70	.497377	11.17	2	.889647	2.63	.5
3	.880199	2.68	.498047	11.17	3	.889805	2.65	.5
4	.880360	2.70	.498717	11.18	4	.889964	2.65	.5
5	9.880522	2.68	0.499388	11.20	5	9.890123	2.63	0.5
6	.880683	2.70	.500060	11.20	6	.890281	2.65	.5
7	.880845	2.68	.500732	11.22	7	.890440	2.63	.5
8	.881006	2.68	.501405	11.22	8	.890598	2.65	.5
9	.881167	2.68	.502078	11.23	9	.890757	2.63	.5
10	9.881328	2.70	0.502752	11.23	10	9.890915	2.63	0.5
11	.881490	2.68	.503426	11.27	11	.891073	2.65	.5
12	.881651	2.68	.504102	11.25	12	.891232	2.63	.5
13	.881812	2.68	.504777	11.28	13	.891390	2.63	.5
14	.881973	2.68	.505454	11.28	14	.891548	2.63	.5
15	9.882134	2.68	0.506131	11.28	15	9.891706	2.63	0.5
16	.882295	2.68	.506808	11.30	16	.891864	2.63	.5
17	.882456	2.68	.507486	11.32	17	.892022	2.63	.5
18	.882617	2.67	.508165	11.32	18	.892180	2.63	.5
19	.882777	2.68	.508844	11.33	19	.892338	2.63	.5
20	9.882938	2.68	0.509524	11.35	20	9.892496	2.63	0.5
21	.883099	2.68	.510205	11.35	21	.892654	2.63	.5
22	.883260	2.67	.510886	11.37	22	.892812	2.62	.5
23	.883420	2.68	.511568	11.37	23	.892969	2.63	.5
24	.883581	2.67	.512250	11.38	24	.893127	2.63	.5
25	9.883741	2.68	0.512933	11.40	25	9.893285	2.62	0.5
26	.883902	2.67	.513617	11.40	26	.893442	2.63	.5
27	.884062	2.68	.514301	11.42	27	.893600	2.63	.5
28	.884223	2.67	.514986	11.43	28	.893758	2.62	.5
29	.884383	2.67	.515672	11.43	29	.893915	2.62	.5
30	9.884543	2.67	0.516358	11.45	30	9.894072	2.63	0.5
31	.884703	2.68	.517045	11.45	31	.894230	2.62	.5
32	.884864	2.67	.517732	11.47	32	.894387	2.62	.5
33	.885024	2.67	.518420	11.48	33	.894544	2.63	.5
34	.885184	2.67	.519109	11.48	34	.894702	2.62	.5
35	9.885344	2.67	0.519798	11.50	35	9.894859	2.62	0.5
36	.885504	2.67	.520488	11.52	36	.895016	2.62	.5
37	.885664	2.67	.521179	11.52	37	.895173	2.62	.5
38	.885824	2.65	.521870	11.53	38	.895330	2.62	.5
39	.885983	2.67	.522562	11.53	39	.895487	2.62	.5
40	9.886143	2.67	0.523254	11.55	40	9.895644	2.62	0.5
41	.886303	2.67	.523947	11.57	41	.895801	2.62	.5
42	.886463	2.65	.524641	11.57	42	.895958	2.62	.5
43	.886622	2.67	.525335	11.58	43	.896115	2.62	.5
44	.886782	2.65	.526030	11.60	44	.896272	2.60	.5
45	9.886941	2.67	0.526726	11.62	45	9.896428	2.62	0.5
46	.887101	2.65	.527423	11.62	46	.896585	2.62	.57
47	.887260	2.67	.528120	11.62	47	.896742	2.60	.57
48	.887420	2.65	.528817	11.65	48	.896898	2.62	.57
49	.887579	2.67	.529516	11.65	49	.897055	2.60	.57
50	9.887739	2.65	0.530215	11.65	50	9.897211	2.62	0.57
51	.887898	2.65	.530914	11.67	51	.897368	2.60	.57
52	.888057	2.65	.531614	11.68	52	.897524	2.60	.57
53	.888216	2.65	.532315	11.70	53	.897680	2.62	.57
54	.888375	2.65	.533017	11.70	54	.897837	2.60	.57
55	9.888534	2.65	0.533719	11.72	55	9.897993	2.60	0.57
56	.888693	2.65	.534422	11.73	56	.898149	2.60	.57
57	.888852	2.65	.535126	11.73	57	.898305	2.60	.57
58	.889011	2.65	.535830	11.75	58	.898461	2.62	.57
59	.889170	2.65	.536535	11.77	59	.898618	2.60	.58
60	9.889329		0.537241		60	9.898774		0.58

30° Sin.	30° Cos.	31° Sin.	31° Cos.	32° Sin.	32° Cos.	33° Sin.	33° Cos.	34° Sin.	34° Cos.	
.50000	.86603	.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	60
025	588	529	702	.53017	789	488	851	943	887	59
050	573	554	687	041	774	513	835	968	871	58
076	559	579	673	066	759	537	819	992	855	57
101	544	604	657	091	743	561	804	.56016	839	56
.50126	.86530	.51628	.85642	.53115	.84728	.54586	.83788	.56040	.82822	55
151	515	653	627	140	712	610	772	064	806	54
176	501	678	612	164	697	635	756	088	790	53
201	486	703	597	189	681	659	740	112	773	52
227	471	728	582	214	666	683	724	136	757	51
.50252	.86457	.51753	.85567	.53238	.84650	.54708	.83708	.56160	.82741	50
277	442	778	551	263	635	732	692	184	724	49
302	427	803	536	288	619	756	676	208	708	48
327	413	828	521	312	604	781	660	232	692	47
352	398	852	506	337	588	805	645	256	675	46
.50377	.86384	.51877	.85491	.53361	.84573	.54829	.83629	.56280	.82659	45
403	369	902	476	386	557	854	613	305	643	44
428	354	927	461	411	542	878	597	329	626	43
453	340	952	446	435	526	902	581	353	610	42
478	325	977	431	460	511	927	565	377	593	41
.50503	.86310	.52002	.85416	.53484	.84495	.54951	.83549	.56401	.82577	40
528	295	026	401	509	480	975	533	425	561	39
553	281	051	385	534	464	999	517	449	544	38
578	266	076	370	558	448	.55024	501	473	528	37
603	251	101	355	583	433	048	485	497	511	36
.50628	.86237	.52126	.85340	.53607	.84417	.55072	.83469	.56521	.82495	35
654	222	151	325	632	402	097	453	545	478	34
679	207	175	310	656	386	121	437	569	462	33
704	192	200	294	681	370	145	421	593	446	32
729	178	225	279	705	355	169	405	617	429	31
.50754	.86163	.52250	.85264	.53730	.84339	.55194	.83389	.56641	.82413	30
779	148	275	249	754	324	218	373	665	396	29
804	133	299	234	779	308	242	356	689	380	28
829	119	324	218	804	292	266	340	713	363	27
854	104	349	203	828	277	291	324	736	347	26
.50879	.86089	.52374	.85188	.53853	.84261	.55315	.83308	.56760	.82330	25
904	074	399	173	877	245	339	292	784	314	24
929	059	423	157	902	230	363	276	808	297	23
954	045	448	142	926	214	388	260	832	281	22
979	030	473	127	951	198	412	244	856	264	21
.51004	.86015	.52498	.85112	.53975	.84182	.55436	.83228	.56880	.82248	20
029	000	522	096	.54000	167	460	212	904	231	19
054	.85985	547	081	024	151	484	195	928	214	18
079	970	572	066	049	135	509	179	952	198	17
104	956	597	051	073	120	533	163	976	181	16
.51129	.85941	.52621	.85035	.54097	.84104	.55557	.83147	.57000	.82165	15
154	926	646	020	122	088	581	131	024	148	14
179	911	671	005	146	072	605	115	047	132	13
204	896	696	.84989	171	057	630	098	071	115	12
229	881	720	974	195	041	654	082	095	098	11
.51254	.85866	.52745	.84959	.54220	.84025	.55678	.83066	.57119	.82082	10
279	851	770	943	244	009	702	050	143	065	9
304	836	794	928	269	.83994	726	034	167	048	8
329	821	819	913	293	978	750	017	191	032	7
354	806	844	897	317	962	775	001	215	015	6
.51379	.85792	.52869	.84882	.54342	.83946	.55799	.82985	.57238	.81999	5
404	777	893	866	366	930	823	969	262	982	4
429	762	918	851	391	915	847	953	286	965	3
454	747	943	836	415	899	871	936	310	949	2
479	732	967	820	440	883	895	920	334	932	1
.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	.57358	.81915	0
Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
59°		58°		57°		56°		55°		

M.	35° Sin.	35° Cos.	36° Sin.	36° Cos.	37° Sin.	37° Cos.	38° Sin.	38° Cos.	39° Sin.	39° Cos.	
0	.57358	.81915	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	60
1	381	899	802	885	205	846	589	783	955	696	59
2	405	882	826	867	228	829	612	765	977	678	58
3	429	865	849	850	251	811	635	747	.63000	660	57
4	453	848	873	833	274	793	658	729	022	641	56
5	.57477	.81832	.58896	.80816	.60298	.79776	.61681	.78711	.63045	.77623	55
6	501	815	920	799	321	758	704	694	068	605	54
7	524	798	943	782	344	741	726	676	090	586	53
8	548	782	967	765	367	723	749	658	113	568	52
9	572	765	990	748	390	706	772	640	135	550	51
10	.57596	.81748	.59014	.80730	.60414	.79688	.61795	.78622	.63158	.77531	50
11	619	731	037	713	437	671	818	604	180	513	49
12	643	714	061	696	460	653	841	586	203	494	48
13	667	698	084	679	483	635	864	568	225	476	47
14	691	681	108	662	506	618	887	550	248	458	46
15	.57715	.81664	.59131	.80644	.60529	.79600	.61909	.78532	.63271	.77439	45
16	738	647	154	627	553	583	932	514	293	421	44
17	762	631	178	610	576	565	955	496	316	402	43
18	786	614	201	593	599	547	978	478	338	384	42
19	810	597	225	576	622	530	.62001	460	361	366	41
20	.57833	.81580	.59248	.80558	.60645	.79512	.62024	.78442	.63383	.77347	40
21	857	563	272	541	668	494	046	424	406	329	39
22	881	546	295	524	691	477	069	405	428	310	38
23	904	530	318	507	714	459	092	387	451	292	37
24	928	513	342	489	738	441	115	369	473	273	36
25	.57952	.81496	.59365	.80472	.60761	.79424	.62138	.78351	.63496	.77255	35
26	976	479	389	455	784	406	160	333	518	236	34
27	999	462	412	438	807	388	183	315	540	218	33
28	.58023	445	436	420	830	371	206	297	563	199	32
29	047	428	459	403	853	353	229	279	585	181	31
30	.58070	.81412	.59482	.80386	.60876	.79335	.62251	.78261	.63608	.77162	30
31	094	395	506	368	899	318	274	243	630	144	29
32	118	378	529	351	922	300	297	225	653	125	28
33	141	361	552	334	945	282	320	206	675	107	27
34	165	344	576	316	968	264	342	188	698	088	26
35	.58189	.81327	.59599	.80299	.60991	.79247	.62365	.78170	.63720	.77070	25
36	212	310	622	282	.61015	229	388	152	742	051	24
37	236	293	646	264	038	211	411	134	765	033	23
38	260	276	669	247	061	193	433	116	787	014	22
39	283	259	693	230	084	176	456	098	810	.76996	21
40	.58307	.81242	.59716	.80212	.61107	.79158	.62479	.78079	.63832	.76977	20
41	330	225	739	195	130	140	502	061	854	959	19
42	354	208	763	178	153	122	524	043	877	940	18
43	378	191	786	160	176	105	547	025	899	921	17
44	401	174	809	143	199	087	570	007	922	903	16
45	.58425	.81157	.59832	.80125	.61222	.79069	.62592	.77988	.63944	.76884	15
46	449	140	856	108	245	051	615	970	966	866	14
47	472	123	879	091	268	033	638	952	989	847	13
48	496	106	902	073	291	016	660	934	.64011	828	12
49	519	089	926	056	314	.78998	683	916	033	810	11
50	.58543	.81072	.59949	.80038	.61337	.78980	.62706	.77897	.64056	.76791	10
51	567	055	972	021	360	962	728	879	078	772	9
52	590	038	995	003	383	944	751	861	100	754	8
53	614	021	.60019	.79986	406	926	774	843	123	735	7
54	637	004	042	968	429	908	796	824	145	717	6
55	.58661	.80987	.60065	.79951	.61451	.78891	.62819	.77806	.64167	.76698	5
56	684	970	089	934	474	873	842	788	190	679	4
57	708	953	112	916	497	855	864	769	212	661	3
58	731	936	135	899	520	837	887	751	234	642	2
59	755	919	158	881	543	819	909	733	256	625	1
60	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	.64279	.76604	0
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
	54°		53°		52°		51°		50°		

40°		41°		42°		43°		44°		
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
	.76604	.65606	.75471	.66913	.74314	.68200	.73135	.69466	.71934	60
	586	628	452	935	295	221	116	487	914	59
	567	650	433	956	276	242	096	508	894	58
	548	672	414	978	256	264	076	529	873	57
	530	694	395	999	237	285	056	549	853	56
	.76511	.65716	.75375	.67021	.74217	.68306	.73036	.69570	.71833	55
	492	738	356	043	198	327	016	591	813	54
	473	759	337	064	178	349	.72996	612	792	53
	455	781	318	086	159	370	976	633	772	52
	436	803	299	107	139	391	957	654	752	51
	.76417	.65825	.75280	.67129	.74120	.68412	.72937	.69675	.71732	50
	398	847	261	151	100	434	917	696	711	49
	380	869	241	172	080	455	897	717	691	48
	361	891	222	194	061	476	877	737	671	47
	342	913	203	215	041	497	857	758	650	46
	.76323	.65935	.75184	.67237	.74022	.68518	.72837	.69779	.71630	45
	304	956	165	258	002	539	817	800	610	44
	286	978	146	280	.73983	561	797	821	590	43
	267	.66000	126	301	963	582	777	842	569	42
	248	022	107	323	944	603	757	862	549	41
	.76229	.66044	.75088	.67344	.73924	.68624	.72737	.69883	.71529	40
	210	066	069	366	904	645	717	904	508	39
	192	088	050	387	885	666	697	925	488	38
	173	109	030	409	865	688	677	946	468	37
	154	131	011	430	846	709	657	966	447	36
	.76135	.66153	.74992	.67452	.73826	.68730	.72637	.69987	.71427	35
	116	175	973	473	806	751	617	.70008	407	34
	097	197	953	495	787	772	597	029	386	33
	078	218	934	516	767	793	577	049	366	32
	059	240	915	538	747	814	557	070	345	31
	.76041	.66262	.74896	.67559	.73728	.68835	.72537	.70091	.71325	30
	022	284	876	580	708	857	517	112	305	29
	003	306	857	602	688	878	497	132	284	28
	.75984	327	838	623	669	899	477	153	264	27
	965	349	818	645	649	920	457	174	243	26
	.75946	.66371	.74799	.67666	.73629	.68941	.72437	.70195	.71223	25
	927	393	780	688	610	962	417	215	203	24
	908	414	760	709	590	983	397	236	182	23
	889	436	741	730	570	.69004	377	257	162	22
	870	458	722	752	551	025	357	277	141	21
	.75851	.66480	.74703	.67773	.73531	.69046	.72337	.70298	.71121	20
	832	501	683	795	511	067	317	319	100	19
	813	523	664	816	491	088	297	339	080	18
	794	545	644	837	472	109	277	360	059	17
	775	566	625	859	452	130	257	381	039	16
	.75756	.66588	.74606	.67880	.73432	.69151	.72236	.70401	.71019	15
	738	610	586	901	413	172	216	422	.70998	14
	719	632	567	923	393	193	196	443	978	13
	700	653	548	944	373	214	176	463	957	12
	680	675	528	965	353	235	156	484	937	11
	.75661	.66697	.74509	.67987	.73333	.69256	.72136	.70505	.70916	10
	642	718	489	.68008	314	277	116	525	896	9
	623	740	470	029	294	298	095	546	875	8
	604	762	451	051	274	319	075	567	855	7
	585	783	431	072	254	340	055	587	834	6
	.75566	.66805	.74412	.68093	.73234	.69361	.72035	.70608	.70813	5
	547	827	392	115	215	382	015	628	793	4
	528	848	373	136	195	403	.71995	649	772	3
	509	870	353	157	175	424	974	670	752	2
	490	891	334	179	155	445	954	690	731	1
	.75471	.66913	.74314	.68200	.73135	.69466	.71934	.70711	.70711	0
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
49°		48°		47°		46°		45°		

88°					89°			
M.	Vers.	D. 1″.	Exsec.	D. 1″.	M.	Vers.	D. 1″.	Exsec.
0	9.984573	2.17	1.441753	62.73	0	9.992354	2.13	1.750498
1	.984703	2.18	.445517	63.23	1	.992482	2.15	.757925
2	.984834	2.18	.449311	63.77	2	.992611	2.13	.765477
3	.984965	2.18	.453137	64.28	3	.992739	2.15	.773158
4	.985096	2.17	.456994	64.82	4	.992868	2.13	.780973
5	9.985226	2.18	1.460883	65.37	5	9.992996	2.13	1.788926
6	.985357	2.17	.464805	65.93	6	.993124	2.15	.797022
7	.985487	2.18	.468761	66.50	7	.993253	2.13	.805268
8	.985618	2.17	.472751	67.07	8	.993381	2.13	.813668
9	.985748	2.18	.476775	67.65	9	.993509	2.13	.822229
10	9.985879	2.17	1.480834	68.25	10	9.993637	2.13	1.830956
11	.986009	2.18	.484929	68.87	11	.993765	2.15	.839858
12	.986140	2.17	.489061	69.48	12	.993894	2.13	.848940
13	.986270	2.17	.493230	70.12	13	.994022	2.13	.858211
14	.986400	2.18	.497437	70.77	14	.994150	2.13	.867679
15	9.986531	2.17	1.501683	71.42	15	9.994278	2.13	1.877351
16	.986661	2.17	.505968	72.08	16	.994406	2.13	.887239
17	.986791	2.17	.510293	72.77	17	.994534	2.13	.897350
18	.986921	2.17	.514659	73.45	18	.994662	2.12	.907697
19	.987051	2.17	.519066	74.17	19	.994789	2.13	.918290
20	9.987181	2.17	1.523516	74.90	20	9.994917	2.13	1.929141
21	.987311	2.17	.528010	75.63	21	.995045	2.13	.940264
22	.987441	2.17	.532548	76.38	22	.995173	2.13	.951672
23	.987571	2.17	.537131	77.15	23	.995301	2.12	.963381
24	.987701	2.17	.541760	77.95	24	.995428	2.13	.975405
25	9.987831	2.17	1.546437	78.73	25	9.995556	2.12	1.987760
26	.987961	2.17	.551161	79.57	26	.995683	2.13	2.000485
27	.988091	2.17	.555935	80.40	27	.995811	2.13	.013578
28	.988221	2.17	.560759	81.25	28	.995939	2.12	.027066
29	.988350	2.17	.565634	82.12	29	.996066	2.12	.040984
30	9.988480	2.17	1.570561	83.02	30	9.996193	2.13	2.055357
31	.988610	2.15	.575542	83.93	31	.996321	2.12	.070202
32	.988739	2.17	.580578	84.87	32	.996448	2.13	.085569
33	.988869	2.15	.585670	85.82	33	.996576	2.12	.101490
34	.988998	2.17	.590819	86.80	34	.996703	2.12	.118008
35	9.989128	2.15	1.596027	87.80	35	9.996830	2.12	2.135168
36	.989257	2.17	.601295	88.83	36	.996957	2.13	.153024
37	.989387	2.15	.606625	89.88	37	.997085	2.12	.171634
38	.989516	2.17	.612018	90.95	38	.997212	2.12	.191066
39	.989646	2.15	.617475	92.05	39	.997339	2.12	.211396
40	9.989775	2.15	1.622998	93.18	40	9.997466	2.12	2.232712
41	.989904	2.17	.628589	94.35	41	.997593	2.12	.255116
42	.990034	2.15	.634250	95.53	42	.997720	2.12	.278723
43	.990163	2.15	.639982	96.77	43	.997847	2.12	.303674
44	.990292	2.15	.645788	98.00	44	.997974	2.12	.330129
45	9.990421	2.15	1.651668	99.30	45	9.998101	2.12	2.358285
46	.990550	2.15	.657626	100.62	46	.998228	2.12	.388375
47	.990679	2.15	.663663	101.97	47	.998355	2.10	.420686
48	.990808	2.15	.669781	103.38	48	.998481	2.12	.455575
49	.990937	2.15	.675984	104.80	49	.998608	2.12	.493490
50	9.991066	2.15	1.682272	106.28	50	9.998735	2.12	2.535009
51	.991195	2.15	.688649	107.80	51	.998862	2.10	.580893
52	.991324	2.15	.695117	109.37	52	.998988	2.12	.632172
53	.991453	2.15	.701679	110.98	53	.999115	2.10	.690291
54	.991582	2.13	.708338	112.65	54	.999241	2.12	.757304
55	9.991710	2.15	1.715097	114.35	55	9.999368	2.10	2.836672
56	.991839	2.15	.721958	116.12	56	.999494	2.12	.933708
57	.991968	2.13	.728925	117.95	57	.999621	2.10	3.058716
58	.992096	2.15	.736002	119.83	58	.999747	2.12	.234
59	.992225	2.15	.743192	121.77	59	.999874	2.10	.536
60	9.992354		1.750498		60	0.000000		

4° Tan.	4° Cot.	5° Tan.	5° Cot.	6° Tan.	6° Cot.	7° Tan.	7° Cot.	M.
.06993	14.3007	.08749	11.4301	.10510	9.51436	.12278	8.14435	60
.07022	.2411	778	.3919	540	.48781	308	.12481	59
051	.1821	807	.3540	569	.46141	338	.10536	58
080	.1235	837	.3163	599	.43515	367	.08600	57
110	.0655	866	.2789	628	.40904	397	.06674	56
.07139	14.0079	.08895	11.2417	.10657	9.38307	.12426	8.04756	55
168	13.9507	925	.2048	687	.35724	456	.02848	54
197	.8940	954	.1681	716	.33155	485	.00948	53
227	.8378	983	.1316	746	.30599	515	7.99058	52
256	.7821	.09013	.0954	775	.28058	544	.97176	51
.07285	13.7267	.09042	11.0594	.10805	9.25530	.12574	7.95302	50
314	.6719	071	.0237	834	.23016	603	.93438	49
344	.6174	101	10.9882	863	.20516	633	.91582	48
373	.5634	130	.9529	893	.18028	662	.89734	47
402	.5098	159	.9178	922	.15554	692	.87895	46
.07431	13.4566	.09189	10.8829	.10952	9.13093	.12722	7.86064	45
461	.4039	218	.8483	981	.10646	751	.84242	44
490	.3515	247	.8139	.11011	.08211	781	.82428	43
519	.2996	277	.7797	040	.05789	810	.80622	42
548	.2480	306	.7457	070	.03379	840	.78825	41
.07578	13.1969	.09335	10.7119	.11099	9.00983	.12869	7.77035	40
607	.1461	365	.6783	128	8.98598	899	.75254	39
636	.0958	394	.6450	158	.96227	929	.73480	38
665	.0458	423	.6118	187	.93867	958	.71715	37
695	12.9962	453	.5789	217	.91520	988	.69957	36
.07724	12.9469	.09482	10.5462	.11246	8.89185	.13017	7.68208	35
753	.8981	511	.5136	276	.86862	047	.66466	34
782	.8496	541	.4813	305	.84551	076	.64732	33
812	.8014	570	.4491	335	.82252	106	.63005	32
841	.7536	600	.4172	364	.79964	136	.61287	31
.07870	12.7062	.09629	10.3854	.11394	8.77689	.13165	7.59575	30
899	.6591	658	.3538	423	.75425	195	.57872	29
929	.6124	688	.3224	452	.73172	224	.56176	28
958	.5660	717	.2913	482	.70931	254	.54487	27
987	.5199	746	.2602	511	.68701	284	.52806	26
.08017	12.4742	.09776	10.2294	.11541	8.66482	.13313	7.51132	25
046	.4288	805	.1988	570	.64275	343	.49465	24
075	.3838	834	.1683	600	.62078	372	.47806	23
104	.3390	864	.1381	629	.59893	402	.46154	22
134	.2946	893	.1080	659	.57718	432	.44509	21
.08163	12.2505	.09923	10.0780	.11688	8.55555	.13461	7.42871	20
192	.2067	952	.0483	718	.53402	491	.41240	19
221	.1632	981	.0187	747	.51259	521	.39616	18
251	.1201	.10011	9.98931	777	.49128	550	.37999	17
280	.0772	040	.96007	806	.47007	580	.36389	16
.08309	12.0346	.10069	9.93101	.11836	8.44896	.13609	7.34786	15
339	11.9923	099	.90211	865	.42795	639	.33190	14
368	.9504	128	.87338	895	.40705	669	.31600	13
397	.9087	158	.84482	924	.38625	698	.30018	12
427	.8673	187	.81641	954	.36555	728	.28442	11
.08456	11.8262	.10216	9.78817	.11983	8.34496	.13758	7.26873	10
485	.7853	246	.76009	.12013	.32446	787	.25310	9
514	.7448	275	.73217	042	.30406	817	.23754	8
544	.7045	305	.70441	072	.28376	846	.22204	7
573	.6645	334	.67680	101	.26355	876	.20661	6
.08602	11.6248	.10363	9.64935	.12131	8.24345	.13906	7.19125	5
632	.5853	393	.62205	160	.22344	935	.17594	4
661	.5461	422	.59490	190	.20352	965	.16071	3
690	.5072	452	.56791	219	.18370	995	.14553	2
720	.4685	481	.54106	249	.16398	.14024	.13042	1
.08749	11.4301	.10510	9.51436	.12278	8.14435	.14054	7.11537	0
Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	
85°		84°		83°		82°		

M.	5°		6°		7°		8°		
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.
0	.08716	.99619	.10453	.99452	.12187	.99255	.13917	.99027	.1564
1	745	617	482	449	216	251	946	023	67
2	774	614	511	446	245	248	975	019	701
3	803	612	540	443	274	244	.14004	015	73
4	831	609	569	440	302	240	033	011	758
5	.08860	.99607	.10597	.99437	.12331	.99237	.14061	.99006	.1578
6	889	604	626	434	360	233	090	002	816
7	918	602	655	431	389	230	119	.98998	845
8	947	599	684	428	418	226	148	994	873
9	976	596	713	424	447	222	177	990	902
10	.09005	.99594	.10742	.99421	.12476	.99219	.14205	.98986	.1593
11	034	591	771	418	504	215	234	982	956
12	063	588	800	415	533	211	263	978	988
13	092	586	829	412	562	208	292	973	.16017
14	121	583	858	409	591	204	320	969	046
15	.09150	.99580	.10887	.99406	.12620	.99200	.14349	.98965	.1607
16	179	578	916	402	649	197	378	961	103
17	208	575	945	399	678	193	407	957	132
18	237	572	973	396	706	189	436	953	160
19	266	570	.11002	393	735	186	464	948	189
20	.09295	.99567	.11031	.99390	.12764	.99182	.14493	.98944	.1621
21	324	564	060	386	793	178	522	940	246
22	353	562	089	383	822	175	551	936	275
23	382	559	118	380	851	171	580	931	304
24	411	556	147	377	880	167	608	927	333
25	.09440	.99553	.11176	.99374	.12908	.99163	.14637	.98923	.1636
26	469	551	205	370	937	160	666	919	390
27	498	548	234	367	966	156	695	914	419
28	527	545	263	364	995	152	723	910	447
29	556	542	291	360	.13024	148	752	906	476
30	.09585	.99540	.11320	.99357	.13053	.99144	.14781	.98902	.1650
31	614	537	349	354	081	141	810	897	533
32	642	534	378	351	110	137	838	893	562
33	671	531	407	347	139	133	867	889	591
34	700	528	436	344	168	129	896	884	620
35	.09729	.99526	.11465	.99341	.13197	.99125	.14925	.98880	.1664
36	758	523	494	337	226	122	954	876	677
37	787	520	523	334	254	118	982	871	706
38	816	517	552	331	283	114	.15011	867	734
39	845	514	580	327	312	110	040	863	763
40	.09874	.99511	.11609	.99324	.13341	.99106	.15069	.98858	.1679
41	903	508	638	320	370	102	097	854	820
42	932	506	667	317	399	098	126	849	849
43	961	503	696	314	427	094	155	845	878
44	990	500	725	310	456	091	184	841	906
45	.10019	.99497	.11754	.99307	.13485	.99087	.15212	.98836	.1693
46	048	494	783	303	514	083	241	832	964
47	077	491	812	300	543	079	270	827	992
48	106	488	840	297	572	075	299	823	.1702
49	135	485	869	293	600	071	327	818	050
50	.10164	.99482	.11898	.99290	.13629	.99067	.15356	.98814	.1707
51	192	479	927	286	658	063	385	809	107
52	221	476	956	283	687	059	414	805	136
53	250	473	985	279	716	055	442	800	164
54	279	470	.12014	276	744	051	471	796	193
55	.10308	.99467	.12043	.99272	.13773	.99047	.15500	.98791	.1722
56	337	464	071	269	802	043	529	787	250
57	366	461	100	265	831	039	557	782	279
58	395	458	129	262	860	035	586	778	308
59	424	455	158	258	889	031	615	773	336
60	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	.1736
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.
	84°		83°		82°		81°		

10°		11°		12°		13°		14°		
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
5	.98481	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	60
3	476	109	157	820	809	523	430	220	023	59
2	471	138	152	848	803	552	424	249	015	58
1	466	167	146	877	797	580	417	277	008	57
9	461	195	140	905	791	608	411	305	001	56
8	.98455	.19224	.98135	.20933	.97784	.22637	.97404	.24333	.96994	55
7	450	252	129	962	778	665	398	362	987	54
5	445	281	124	990	772	693	391	390	980	53
4	440	309	118	.21019	766	722	384	418	973	52
3	435	338	112	047	760	750	378	446	966	51
1	.98430	.19366	.98107	.21076	.97754	.22778	.97371	.24474	.96959	50
0	425	395	101	104	748	807	365	503	952	49
8	420	423	096	132	742	835	358	531	945	48
7	414	452	090	161	735	863	351	559	937	47
6	409	481	084	189	729	892	345	587	930	46
4	.98404	.19509	.98079	.21218	.97723	.22920	.97338	.24615	.96923	45
3	399	538	073	246	717	948	331	644	916	44
2	394	566	067	275	711	977	325	672	909	43
0	389	595	061	303	705	.23005	318	700	902	42
0	383	623	056	331	698	033	311	728	894	41
7	.98378	.19652	.98050	.21360	.97692	.23062	.97304	.24756	.96887	40
6	373	680	044	388	686	090	298	784	880	39
5	368	709	039	417	680	118	291	813	873	38
4	362	737	033	445	673	146	284	841	866	37
3	357	766	027	474	667	175	278	869	858	36
1	.98352	.19794	.98021	.21502	.97661	.23203	.97271	.24897	.96851	35
0	347	823	016	530	655	231	264	925	844	34
9	341	851	010	559	648	260	257	954	837	33
8	336	880	004	587	642	288	251	982	829	32
7	331	908	.97998	616	636	316	244	.25010	822	31
5	.98325	.19937	.97992	.21644	.97630	.23345	.97237	.25038	.96815	30
4	320	965	987	672	623	373	230	066	807	29
3	315	994	981	701	617	401	223	094	800	28
2	310	.20022	975	729	611	429	217	122	793	27
1	304	051	969	758	604	458	210	151	786	26
0	.98299	.20079	.97963	.21786	.97598	.23486	.97203	.25179	.96778	25
8	294	108	958	814	592	514	196	207	771	24
7	288	136	952	843	585	542	189	235	764	23
6	283	165	946	871	579	571	182	263	756	22
5	277	193	940	899	573	599	176	291	749	21
4	.98272	.20222	.97934	.21928	.97566	.23627	.97169	.25320	.96742	20
3	267	250	928	956	560	656	162	348	734	19
2	261	279	922	985	553	684	155	376	727	18
1	256	307	916	.22013	547	712	148	404	719	17
0	250	336	910	041	541	740	141	432	712	16
9	.98245	.20364	.97905	.22070	.97534	.23769	.97134	.25460	.96705	15
8	240	393	899	098	528	797	127	488	697	14
7	234	421	893	126	521	825	120	516	690	13
6	229	450	887	155	515	853	113	545	682	12
5	223	478	881	183	508	882	106	573	675	11
4	.98218	.20507	.97875	.22212	.97502	.23910	.97100	.25601	.96667	10
3	212	535	869	240	496	938	093	629	660	9
2	207	563	863	268	489	966	086	657	653	8
1	201	592	857	297	483	995	079	685	645	7
0	196	620	851	325	476	.24023	072	713	638	6
9	.98190	.20649	.97845	.22353	.97470	.24051	.97065	.25741	.96630	5
8	185	677	839	382	463	079	058	769	623	4
7	179	706	833	410	457	108	051	798	615	3
6	174	734	827	438	450	136	044	826	608	2
5	168	763	821	467	444	164	037	854	600	1
4	.98163	.20791	.97815	.22495	.97437	.24192	.97030	.25882	.96593	0
9°	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
		78°		77°		76°		75°		

M.	5°		6°		7°		8°		
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.
0	.08716	.99619	.10453	.99452	.12187	.99255	.13917	.99027	.1564
1	745	617	482	449	216	251	946	023	672
2	774	614	511	446	245	248	975	019	701
3	803	612	540	443	274	244	.14004	015	730
4	831	609	569	440	302	240	033	011	758
5	.08860	.99607	.10597	.99437	.12331	.99237	.14061	.99006	.1578
6	889	604	626	434	360	233	090	002	816
7	918	602	655	431	389	230	119	.98998	845
8	947	599	684	428	418	226	148	994	873
9	976	596	713	424	447	222	177	990	902
10	.09005	.99594	.10742	.99421	.12476	.99219	.14205	.98986	.1593
11	034	591	771	418	504	215	234	982	959
12	063	588	800	415	533	211	263	978	988
13	092	586	829	412	562	208	292	973	.1601
14	121	583	858	409	591	204	320	969	046
15	.09150	.99580	.10887	.99406	.12620	.99200	.14349	.98965	.1607
16	179	578	916	402	649	197	378	961	103
17	208	575	945	399	678	193	407	957	132
18	237	572	973	396	706	189	436	953	160
19	266	570	.11002	393	735	186	464	948	189
20	.09295	.99567	.11031	.99390	.12764	.99182	.14493	.98944	.1621
21	324	564	060	386	793	178	522	940	246
22	353	562	089	383	822	175	551	936	275
23	382	559	118	380	851	171	580	931	304
24	411	556	147	377	880	167	608	927	333
25	.09440	.99553	.11176	.99374	.12908	.99163	.14637	.98923	.1636
26	469	551	205	370	937	160	666	919	390
27	498	548	234	367	966	156	695	914	419
28	527	545	263	364	995	152	723	910	447
29	556	542	291	360	.13024	148	752	906	476
30	.09585	.99540	.11320	.99357	.13053	.99144	.14781	.98902	.1650
31	614	537	349	354	081	141	810	897	533
32	642	534	378	351	110	137	838	893	562
33	671	531	407	347	139	133	867	889	591
34	700	528	436	344	168	129	896	884	620
35	.09729	.99526	.11465	.99341	.13197	.99125	.14925	.98880	.1664
36	758	523	494	337	226	122	954	876	677
37	787	520	523	334	254	118	982	871	706
38	816	517	552	331	283	114	.15011	867	734
39	845	514	580	327	312	110	040	863	763
40	.09874	.99511	.11609	.99324	.13341	.99106	.15069	.98858	.1679
41	903	508	638	320	370	102	097	854	820
42	932	506	667	317	399	098	126	849	849
43	961	503	696	314	427	094	155	845	878
44	990	500	725	310	456	091	184	841	906
45	.10019	.99497	.11754	.99307	.13485	.99087	.15212	.98836	.1693
46	048	494	783	303	514	083	241	832	964
47	077	491	812	300	543	079	270	827	992
48	106	488	840	297	572	075	299	823	.1702
49	135	485	869	293	600	071	327	818	050
50	.10164	.99482	.11898	.99290	.13629	.99067	.15356	.98814	.1707
51	192	479	927	286	658	063	385	809	107
52	221	476	956	283	687	059	414	805	136
53	250	473	985	279	716	055	442	800	164
54	279	470	.12014	276	744	051	471	796	193
55	.10308	.99467	.12043	.99272	.13773	.99047	.15500	.98791	.1722
56	337	464	071	269	802	043	529	787	250
57	366	461	100	265	831	039	557	782	279
58	395	458	129	262	860	035	586	778	308
59	424	455	158	258	889	031	615	773	336
60	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	.1736
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Co
	84°		83°		82°		81°		

20° Sin.	20° Cos.	21° Sin.	21° Cos.	22° Sin.	22° Cos.	23° Sin.	23° Cos.	24° Sin.	24° Cos.	
.34202	.93969	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	60
229	959	864	348	488	707	100	039	700	343	59
257	949	891	337	515	697	127	028	727	331	58
284	939	918	327	542	686	153	016	753	319	57
311	929	945	316	569	675	180	005	780	307	56
.34339	.93919	.35973	.93306	.37595	.92664	.39207	.91994	.40806	.91295	55
366	909	.36000	295	622	653	234	982	833	283	54
393	899	027	285	649	642	260	971	860	272	53
421	889	054	274	676	631	287	959	886	260	52
448	879	081	264	703	620	314	948	913	248	51
.34475	.93869	.36108	.93253	.37730	.92609	.39341	.91936	.40939	.91236	50
503	859	135	243	757	598	367	925	966	224	49
530	849	162	232	784	587	394	914	992	212	48
557	839	190	222	811	576	421	902	.41019	200	47
584	829	217	211	838	565	448	891	045	188	46
.34612	.93819	.36244	.93201	.37865	.92554	.39474	.91879	.41072	.91176	45
639	809	271	190	892	543	501	868	098	164	44
666	799	298	180	919	532	528	856	125	152	43
694	789	325	169	946	521	555	845	151	140	42
721	779	352	159	973	510	581	833	178	128	41
.34748	.93769	.36379	.93148	.37999	.92499	.39608	.91822	.41204	.91116	40
775	759	406	137	.38026	488	635	810	231	104	39
803	748	434	127	053	477	661	799	257	092	38
830	738	461	116	080	466	688	787	284	080	37
857	728	488	106	107	455	715	775	310	068	36
.34884	.93718	.36515	.93095	.38134	.92444	.39741	.91764	.41337	.91056	35
912	708	542	084	161	432	768	752	363	044	34
939	698	569	074	188	421	795	741	390	032	33
966	688	596	063	215	410	822	729	416	020	32
993	677	623	052	241	399	848	718	443	008	31
.35021	.93667	.36650	.93042	.38268	.92388	.39875	.91706	.41469	.90996	30
048	657	677	031	295	377	902	694	496	984	29
075	647	704	020	322	366	928	683	522	972	28
102	637	731	010	349	355	955	671	549	960	27
130	626	758	.92999	376	343	982	660	575	948	26
.35157	.93616	.36785	.92988	.38403	.92332	.40008	.91648	.41602	.90936	25
184	606	812	978	430	321	035	636	628	924	24
211	596	839	967	456	310	062	625	655	911	23
239	585	867	956	483	299	088	613	681	899	22
266	575	894	945	510	287	115	601	707	887	21
.35293	.93565	.36921	.92935	.38537	.92276	.40141	.91590	.41734	.90875	20
320	555	948	924	564	265	168	578	760	863	19
347	544	975	913	591	254	195	566	787	851	18
375	534	.37002	902	617	243	221	555	813	839	17
402	524	029	892	644	231	248	543	840	826	16
.35429	.93514	.37056	.92881	.38671	.92220	.40275	.91531	.41866	.90814	15
456	503	083	870	698	209	301	519	892	802	14
484	493	110	859	725	198	328	508	919	790	13
511	483	137	849	752	186	355	496	945	778	12
538	472	164	838	778	175	381	484	972	766	11
.35565	.93462	.37191	.92827	.38805	.92164	.40408	.91472	.41998	.90753	10
592	452	218	816	832	152	434	461	.42024	741	9
619	441	245	805	859	141	461	449	051	729	8
647	431	272	794	886	130	488	437	077	717	7
674	420	299	784	912	119	514	425	104	704	6
.35701	.93410	.37326	.92773	.38939	.92107	.40541	.91414	.42130	.90692	5
728	400	353	762	966	096	567	402	156	680	4
755	389	380	751	993	085	594	390	183	668	3
782	379	407	740	.39020	073	621	378	209	655	2
810	368	434	729	046	062	647	366	235	643	1
.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	.42262	.90631	0
Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
69°		68°		67°		66°		65°		

M.	15°		16°		17°		18°		19°	
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos
0	.25882	.96593	.27564	.96126	.29237	.95630	.30902	.95106	.32557	.9455
1	910	585	592	118	265	622	929	097	584	54
2	938	578	620	110	293	613	957	088	612	53
3	966	570	648	102	321	605	985	079	639	52
4	994	562	676	094	348	596	.31012	070	667	51
5	.26022	.96555	.27704	.96086	.29376	.95588	.31040	.95061	.32694	.9450
6	050	547	731	078	404	579	068	052	722	49
7	079	540	759	070	432	571	095	043	749	48
8	107	532	787	062	460	562	123	033	777	47
9	135	524	815	054	487	554	151	024	804	46
10	.26163	.96517	.27843	.96046	.29515	.95545	.31178	.95015	.32832	.9445
11	191	509	871	037	543	536	206	006	859	44
12	219	502	899	029	571	528	233	.94997	887	43
13	247	494	927	021	599	519	261	988	914	42
14	275	486	955	013	626	511	289	979	942	41
15	.26303	.96479	.27983	.96005	.29654	.95502	.31316	.94970	.32969	.9440
16	331	471	.28011	.95997	682	493	344	961	997	39
17	359	463	039	989	710	485	372	952	.33024	39
18	387	456	067	981	737	476	399	943	051	38
19	415	448	095	972	765	467	427	933	079	37
20	.26443	.96440	.28123	.95964	.29793	.95459	.31454	.94924	.33106	.9436
21	471	433	150	956	821	450	482	915	134	35
22	500	425	178	948	849	441	510	906	161	34
23	528	417	206	940	876	433	537	897	189	33
24	556	410	234	931	904	424	565	888	216	32
25	.26584	.96402	.28262	.95923	.29932	.95415	.31593	.94878	.33244	.9431
26	612	394	290	915	960	407	620	869	271	30
27	640	386	318	907	987	398	648	860	298	29
28	668	379	346	898	.30015	389	675	851	326	28
29	696	371	374	890	043	380	703	842	353	27
30	.26724	.96363	.28402	.95882	.30071	.95372	.31730	.94832	.33381	.9426
31	752	355	429	874	098	363	758	823	408	25
32	780	347	457	865	126	354	786	814	436	24
33	808	340	485	857	154	345	813	805	463	23
34	836	332	513	849	182	337	841	795	490	22
35	.26864	.96324	.28541	.95841	.30209	.95328	.31868	.94786	.33518	.9421
36	892	316	569	832	237	319	896	777	545	20
37	920	308	597	824	265	310	923	768	573	19
38	948	301	625	816	292	301	951	758	600	18
39	976	293	652	807	320	293	979	749	627	17
40	.27004	.96285	.28680	.95799	.30348	.95284	.32006	.94740	.33655	.9416
41	032	277	708	791	376	275	034	730	682	15
42	060	269	736	782	403	266	061	721	710	14
43	088	261	764	774	431	257	089	712	737	13
44	116	253	792	766	459	248	116	702	764	12
45	.27144	.96246	.28820	.95757	.30486	.95240	.32144	.94693	.33792	.9411
46	172	238	847	749	514	231	171	684	819	10
47	200	230	875	740	542	222	199	674	846	09
48	228	222	903	732	570	213	227	665	874	08
49	256	214	931	724	597	204	254	656	901	07
50	.27284	.96206	.28959	.95715	.30625	.95195	.32282	.94646	.33929	.9406
51	312	198	987	707	653	186	309	637	956	05
52	340	190	.29015	698	680	177	337	627	983	04
53	368	182	042	690	708	168	364	618	.34011	03
54	396	174	070	681	736	159	392	609	038	02
55	.27424	.96166	.29098	.95673	.30763	.95150	.32419	.94599	.34065	.9401
56	452	158	126	664	791	142	447	590	093	00
57	480	150	154	656	819	133	474	580	120	.9399
58	508	142	182	647	846	124	502	571	147	98
59	536	134	209	639	874	115	529	561	175	97
60	.27564	.96126	.29237	.95630	.30902	.95106	.32557	.94552	.34202	.9395
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	S
	74°		73°		72°		71°		70	

20° Sin.	20° Cos.	21° Sin.	21° Cos.	22° Sin.	22° Cos.	23° Sin.	23° Cos.	24° Sin.	24° Cos.	
.34202	.93969	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	60
229	959	864	348	488	707	100	039	700	343	59
257	949	891	337	515	697	127	028	727	331	58
284	939	918	327	542	686	153	016	753	319	57
311	929	945	316	569	675	180	005	780	307	56
.34339	.93919	.35973	.93306	.37595	.92664	.39207	.91994	.40806	.91295	55
366	909	.36000	295	622	653	234	982	833	283	54
393	899	027	285	649	642	260	971	860	272	53
421	889	054	274	676	631	287	959	886	260	52
448	879	081	264	703	620	314	948	913	248	51
.34475	.93869	.36108	.93253	.37730	.92609	.39341	.91936	.40939	.91236	50
503	859	135	243	757	598	367	925	966	224	49
530	849	162	232	784	587	394	914	992	212	48
557	839	190	222	811	576	421	902	.41019	200	47
584	829	217	211	838	565	448	891	045	188	46
.34612	.93819	.36244	.93201	.37865	.92554	.39474	.91879	.41072	.91176	45
639	809	271	190	892	543	501	868	098	164	44
666	799	298	180	919	532	528	856	125	152	43
694	789	325	169	946	521	555	845	151	140	42
721	779	352	159	973	510	581	833	178	128	41
.34748	.93769	.36379	.93148	.37999	.92499	.39608	.91822	.41204	.91116	40
775	759	406	137	.38026	488	635	810	231	104	39
803	748	434	127	053	477	661	799	257	092	38
830	738	461	116	080	466	688	787	284	080	37
857	728	488	106	107	455	715	775	310	068	36
.34884	.93718	.36515	.93095	.38134	.92444	.39741	.91764	.41337	.91056	35
912	708	542	084	161	432	768	752	363	044	34
939	698	569	074	188	421	795	741	390	032	33
966	688	596	063	215	410	822	729	416	020	32
993	677	623	052	241	399	848	718	443	008	31
.35021	.93667	.36650	.93042	.38268	.92388	.39875	.91706	.41469	.90996	30
048	657	677	031	295	377	902	694	496	984	29
075	647	704	020	322	366	928	683	522	972	28
102	637	731	010	349	355	955	671	549	960	27
130	626	758	.92999	376	343	982	660	575	948	26
.35157	.93616	.36785	.92988	.38403	.92332	.40008	.91648	.41602	.90936	25
184	606	812	978	430	321	035	636	628	924	24
211	596	839	967	456	310	062	625	655	911	23
239	585	867	956	483	299	088	613	681	899	22
266	575	894	945	510	287	115	601	707	887	21
.35293	.93565	.36921	.92935	.38537	.92276	.40141	.91590	.41734	.90875	20
320	555	948	924	564	265	168	578	760	863	19
347	544	975	913	591	254	195	566	787	851	18
375	534	.37002	902	617	243	221	555	813	839	17
402	524	029	892	644	231	248	543	840	826	16
.35429	.93514	.37056	.92881	.38671	.92220	.40275	.91531	.41866	.90814	15
456	503	083	870	698	209	301	519	892	802	14
484	493	110	859	725	198	328	508	919	790	13
511	483	137	849	752	186	355	496	945	778	12
538	472	164	838	778	175	381	484	972	766	11
.35565	.93462	.37191	.92827	.38805	.92164	.40408	.91472	.41998	.90753	10
592	452	218	816	832	152	434	461	.42024	741	9
619	441	245	805	859	141	461	449	051	729	8
647	431	272	794	886	130	488	437	077	717	7
674	420	299	784	912	119	514	425	104	704	6
.35701	.93410	.37326	.92773	.38939	.92107	.40541	.91414	.42130	.90692	5
728	400	353	762	966	096	567	402	156	680	4
755	389	380	751	993	085	594	390	183	668	3
782	379	407	740	.39020	073	621	378	209	655	2
810	368	434	729	046	062	647	366	235	643	1
.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	.42262	.90631	0
Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M
69°		68°		67°		66°		65°		

M.	25°		26°		27°		28°		29°	
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.
0	.42262	.90631	.43837	.89879	.45399	.89101	.46947	.88295	.48481	.87462
1	288	618	863	867	425	087	973	281	506	448
2	315	606	889	854	451	074	999	267	532	434
3	341	594	916	841	477	061	.47024	254	557	420
4	367	582	942	828	503	048	050	240	583	406
5	.42394	.90569	.43968	.89816	.45529	.89035	.47076	.88226	.48608	.87391
6	420	557	994	803	554	021	101	213	634	377
7	446	545	.44020	790	580	008	127	199	659	363
8	473	532	046	777	606	.88995	153	185	684	349
9	499	520	072	764	632	981	178	172	710	335
10	.42525	.90507	.44098	.89752	.45658	.88968	.47204	.88158	.48735	.87321
11	552	495	124	739	684	955	229	144	761	306
12	578	483	151	726	710	942	255	130	786	292
13	604	470	177	713	736	928	281	117	811	278
14	631	458	203	700	762	915	306	103	837	264
15	.42657	.90446	.44229	.89687	.45787	.88902	.47332	.88089	.48862	.87250
16	683	433	255	674	813	888	358	075	888	235
17	709	421	281	662	839	875	383	062	913	221
18	736	408	307	649	865	862	409	048	938	207
19	762	396	333	636	891	848	434	034	964	193
20	.42788	.90383	.44359	.89623	.45917	.88835	.47460	.88020	.48989	.87178
21	815	371	385	610	942	822	486	006	.49014	164
22	841	358	411	597	968	808	511	.87993	040	150
23	867	346	437	584	994	795	537	979	065	136
24	894	334	464	571	.46020	782	562	965	090	121
25	.42920	.90321	.44490	.89558	.46046	.88768	.47588	.87951	.49116	.87107
26	946	309	516	545	072	755	614	937	141	093
27	972	296	542	532	097	741	639	923	166	079
28	999	284	568	519	123	728	665	909	192	064
29	.43025	271	594	506	149	715	690	896	217	050
30	.43051	.90259	.44620	.89493	.46175	.88701	.47716	.87882	.49242	.87036
31	077	246	646	480	201	688	741	868	268	021
32	104	233	672	467	226	674	767	854	293	007
33	130	221	698	454	252	661	793	840	318	.86993
34	156	208	724	441	278	647	818	826	344	978
35	.43182	.90196	.44750	.89428	.46304	.88634	.47844	.87812	.49369	.86964
36	209	183	776	415	330	620	869	798	394	949
37	235	171	802	402	355	607	895	784	419	935
38	261	158	828	389	381	593	920	770	445	921
39	287	146	854	376	407	580	946	756	470	906
40	.43313	.90133	.44880	.89363	.46433	.88566	.47971	.87743	.49495	.86892
41	340	120	906	350	458	553	997	729	521	878
42	366	108	932	337	484	539	.48022	715	546	863
43	392	095	958	324	510	526	048	701	571	849
44	418	082	984	311	536	512	073	687	596	834
45	.43445	.90070	.45010	.89298	.46561	.88499	.48099	.87673	.49622	.86820
46	471	057	036	285	587	485	124	659	647	805
47	497	045	062	272	613	472	150	645	672	791
48	523	032	088	259	639	458	175	631	697	777
49	549	019	114	245	664	445	201	617	723	762
50	.43575	.90007	.45140	.89232	.46690	.88431	.48226	.87603	.49748	.86748
51	602	.89994	166	219	716	417	252	589	773	733
52	628	981	192	206	742	404	277	575	798	719
53	654	968	218	193	767	390	303	561	824	704
54	680	956	243	180	793	377	328	546	849	690
55	.43706	.89943	.45269	.89167	.46819	.88363	.48354	.87532	.49874	.86675
56	733	930	295	153	844	349	379	518	899	661
57	759	918	321	140	870	336	405	504	924	646
58	785	905	347	127	896	322	430	490	950	632
59	811	892	373	114	921	308	456	476	975	617
60	.43837	.89879	.45399	.89101	.46947	.88295	.48481	.87462	.50000	.86603
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
	64°		63°		62°		61°		6	

40°		41°		42°		43°		44°		
	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	
	.76604	.65606	.75471	.66913	.74314	.68200	.73135	.69466	.71934	60
	586	628	452	935	295	221	116	487	914	59
	567	650	433	956	276	242	096	508	894	58
	548	672	414	978	256	264	076	529	873	57
	530	694	395	999	237	285	056	549	853	56
	.76511	.65716	.75375	.67021	.74217	.68306	.73036	.69570	.71833	55
	492	738	356	043	198	327	016	591	813	54
	473	759	337	064	178	349	.72996	612	792	53
	455	781	318	086	159	370	976	633	772	52
	436	803	299	107	139	391	957	654	752	51
	.76417	.65825	.75280	.67129	.74120	.68412	.72937	.69675	.71732	50
	398	847	261	151	100	434	917	696	711	49
	380	869	241	172	080	455	897	717	691	48
	361	891	222	194	061	476	877	737	671	47
	342	913	203	215	041	497	857	758	650	46
	.76323	.65935	.75184	.67237	.74022	.68518	.72837	.69779	.71630	45
	304	956	165	258	002	539	817	800	610	44
	286	978	146	280	.73983	561	797	821	590	43
	267	.66000	126	301	963	582	777	842	569	42
	248	022	107	323	944	603	757	862	549	41
	.76229	.66044	.75088	.67344	.73924	.68624	.72737	.69883	.71529	40
	210	066	069	366	904	645	717	904	508	39
	192	088	050	387	885	666	697	925	488	38
	173	109	030	409	865	688	677	946	468	37
	154	131	011	430	846	709	657	966	447	36
	.76135	.66153	.74992	.67452	.73826	.68730	.72637	.69987	.71427	35
	116	175	973	473	806	751	617	.70008	407	34
	097	197	953	495	787	772	597	029	386	33
	078	218	934	516	767	793	577	049	366	32
	059	240	915	538	747	814	557	070	345	31
	.76041	.66262	.74896	.67559	.73728	.68835	.72537	.70091	.71325	30
	022	284	876	580	708	857	517	112	305	29
	003	306	857	602	688	878	497	132	284	28
	.75984	327	838	623	669	899	477	153	264	27
	965	349	818	645	649	920	457	174	243	26
	.75946	.66371	.74799	.67666	.73629	.68941	.72437	.70195	.71223	25
	927	393	780	688	610	962	417	215	203	24
	908	414	760	709	590	983	397	236	182	23
	889	436	741	730	570	.69004	377	257	162	22
	870	458	722	752	551	025	357	277	141	21
	.75851	.66480	.74703	.67773	.73531	.69046	.72337	.70298	.71121	20
	832	501	683	795	511	067	317	319	100	19
	813	523	664	816	491	088	297	339	080	18
	794	545	644	837	472	109	277	360	059	17
	775	566	625	859	452	130	257	381	039	16
	.75756	.66588	.74606	.67880	.73432	.69151	.72236	.70401	.71019	15
	738	610	586	901	413	172	216	422	.70998	14
	719	632	567	923	393	193	196	443	978	13
	700	653	548	944	373	214	176	463	957	12
	680	675	528	965	353	235	156	484	937	11
	.75661	.66697	.74509	.67987	.73333	.69256	.72136	.70505	.70916	10
	642	718	489	.68008	314	277	116	525	896	9
	623	740	470	029	294	298	095	546	875	8
	604	762	451	051	274	319	075	567	855	7
	585	783	431	072	254	340	055	587	834	6
	.75566	.66805	.74412	.68093	.73234	.69361	.72035	.70608	.70813	5
	547	827	392	115	215	382	015	628	793	4
	528	848	373	136	195	403	.71995	649	772	3
	509	870	353	157	175	424	974	670	752	2
	490	891	334	179	155	445	954	690	731	1
	.75471	.66913	.74314	.68200	.73135	.69466	.71934	.70711	.70711	0
	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	Cos.	Sin.	M.
49°		48°		47°		46°		45°		

M.	0°		1°		2°		3°	
	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	
0	.00000	∞	.01746	57.2900	.03492	28.6363	.05241	1
1	029	3437.75	775	56.3506	521	.3994	270	1
2	058	1718.87	804	55.4415	550	.1664	299	
3	087	1145.92	833	54.5613	579	27.9372	328	
4	116	859.436	862	53.7086	609	.7117	357	
5	.00145	687.549	.01891	52.8821	.03638	27.4899	.05387	1
6	175	572.957	920	52.0807	667	.2715	416	
7	204	491.106	949	51.3032	696	.0566	445	
8	233	429.718	978	50.5485	725	26.8450	474	
9	262	381.971	.02007	49.8157	754	.6367	503	
10	.00291	343.774	.02036	49.1039	.03783	26.4316	.05533	1
11	320	312.521	066	48.4121	812	.2296	562	1
12	349	286.478	095	47.7395	842	.0307	591	
13	378	264.441	124	47.0853	871	25.8348	620	
14	407	245.552	153	46.4489	900	.6418	649	
15	.00436	229.182	.02182	45.8294	.03929	25.4517	.05678	1
16	465	214.858	211	45.2261	958	.2644	708	
17	495	202.219	240	44.6386	987	.0798	737	
18	524	190.984	269	44.0661	.04016	24.8978	766	
19	553	180.932	298	43.5081	046	.7185	795	
20	.00582	171.885	.02328	42.9641	.04075	24.5418	.05824	1
21	611	163.700	357	42.4335	104	.3675	854	
22	640	156.259	386	41.9158	133	.1957	883	1
23	669	149.465	415	41.4106	162	.0263	912	
24	698	143.237	444	40.9174	191	23.8593	941	
25	.00727	137.507	.02473	40.4358	.04220	23.6945	.05970	1
26	756	132.219	502	39.9655	250	.5321	999	
27	785	127.321	531	39.5059	279	.3718	.06029	
28	815	122.774	560	39.0568	308	.2137	058	
29	844	118.540	589	38.6177	337	.0577	087	
30	.00873	114.589	.02619	38.1885	.04366	22.9038	.06116	1
31	902	110.892	648	37.7686	395	.7519	145	
32	931	107.426	677	37.3579	424	.6020	175	
33	960	104.171	706	36.9560	454	.4541	204	
34	989	101.107	735	36.5627	483	.3081	233	
35	.01018	98.2179	.02764	36.1776	.04512	22.1640	.06262	1
36	047	95.4895	793	35.8006	541	.0217	291	
37	076	92.9085	822	35.4313	570	21.8813	321	
38	105	90.4633	851	35.0695	599	.7426	350	
39	135	88.1436	881	34.7151	628	.6056	379	
40	.01164	85.9398	.02910	34.3678	.04658	21.4704	.06408	1
41	193	83.8435	939	34.0273	687	.3369	438	
42	222	81.8470	968	33.6935	716	.2049	467	
43	251	79.9434	997	33.3662	745	.0747	496	
44	280	78.1263	.03026	33.0452	774	20.9460	525	
45	.01309	76.3900	.03055	32.7303	.04803	20.8188	.06554	1
46	338	74.7292	084	32.4213	833	.6932	584	
47	367	73.1390	114	32.1181	862	.5691	613	
48	396	71.6151	143	31.8205	891	.4465	642	
49	425	70.1533	172	31.5284	920	.3253	671	
50	.01455	68.7501	.03201	31.2416	.04949	20.2056	.06700	1
51	484	67.4019	230	30.9599	978	.0872	730	
52	513	66.1055	259	30.6833	.05007	19.9702	759	
53	542	64.8580	288	30.4116	037	.8546	788	
54	571	63.6567	317	30.1446	066	.7403	817	
55	.01600	62.4992	.03346	29.8823	.05095	19.6273	.06847	1
56	629	61.3829	376	29.6245	124	.5156	876	
57	658	60.3058	405	29.3711	153	.4051	905	
58	687	59.2659	434	29.1220	182	.2959	934	
59	716	58.2612	463	28.8771	212	.1879	963	
60	.01746	57.2900	.03492	28.6363	.05241	19.0811	.06993	
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	
	89°		88°		87°			

4°		5°		6°		7°		
Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	
.06993	14.3007	.08749	11.4301	.10510	9.51436	.12278	8.14435	60
.07022	.2411	778	.3919	540	.48781	308	.12481	59
051	.1821	807	.3540	569	.46141	338	.10536	58
080	.1235	837	.3163	599	.43515	367	.08600	57
110	.0655	866	.2789	628	.40904	397	.06674	56
.07139	14.0079	.08895	11.2417	.10657	9.38307	.12426	8.04756	55
168	13.9507	925	.2048	687	.35724	456	.02848	54
197	.8940	954	.1681	716	.33155	485	.00948	53
227	.8378	983	.1316	746	.30599	515	7.99058	52
256	.7821	.09013	.0954	775	.28058	544	.97176	51
.07285	13.7267	.09042	11.0594	.10805	9.25530	.12574	7.95302	50
314	.6719	071	.0237	834	.23016	603	.93438	49
344	.6174	101	10.9882	863	.20516	633	.91582	48
373	.5634	130	.9529	893	.18028	662	.89734	47
402	.5098	159	.9178	922	.15554	692	.87895	46
.07431	13.4566	.09189	10.8829	.10952	9.13093	.12722	7.86064	45
461	.4039	218	.8483	981	.10646	751	.84242	44
490	.3515	247	.8139	.11011	.08211	781	.82428	43
519	.2996	277	.7797	040	.05789	810	.80622	42
548	.2480	306	.7457	070	.03379	840	.78825	41
.07578	13.1969	.09335	10.7119	.11099	9.00983	.12869	7.77035	40
607	.1461	365	.6783	128	8.98598	899	.75254	39
636	.0958	394	.6450	158	.96227	929	.73480	38
665	.0458	423	.6118	187	.93867	958	.71715	37
695	12.9962	453	.5789	217	.91520	988	.69957	36
.07724	12.9469	.09482	10.5462	.11246	8.89185	.13017	7.68208	35
753	.8981	511	.5136	276	.86862	047	.66466	34
782	.8496	541	.4813	305	.84551	076	.64732	33
812	.8014	570	.4491	335	.82252	106	.63005	32
841	.7536	600	.4172	364	.79964	136	.61287	31
.07870	12.7062	.09629	10.3854	.11394	8.77689	.13165	7.59575	30
899	.6591	658	.3538	423	.75425	195	.57872	29
929	.6124	688	.3224	452	.73172	224	.56176	28
958	.5660	717	.2913	482	.70931	254	.54487	27
987	.5199	746	.2602	511	.68701	284	.52806	26
.08017	12.4742	.09776	10.2294	.11541	8.66482	.13313	7.51132	25
046	.4288	805	.1988	570	.64275	343	.49465	24
075	.3838	834	.1683	600	.62078	372	.47806	23
104	.3390	864	.1381	629	.59893	402	.46154	22
134	.2946	893	.1080	659	.57718	432	.44509	21
.08163	12.2505	.09923	10.0780	.11688	8.55555	.13461	7.42871	20
192	.2067	952	.0483	718	.53402	491	.41240	19
221	.1632	981	.0187	747	.51259	521	.39616	18
251	.1201	.10011	9.98931	777	.49128	550	.37999	17
280	.0772	040	.96007	806	.47007	580	.36389	16
.08309	12.0346	.10069	9.93101	.11836	8.44896	.13609	7.34786	15
339	11.9923	099	.90211	865	.42795	639	.33190	14
368	.9504	128	.87338	895	.40705	669	.31600	13
397	.9087	158	.84482	924	.38625	698	.30018	12
427	.8673	187	.81641	954	.36555	728	.28442	11
.08456	11.8262	.10216	9.78817	.11983	8.34496	.13758	7.26873	10
485	.7853	246	.76009	.12013	.32446	787	.25310	9
514	.7448	275	.73217	042	.30406	817	.23754	8
544	.7045	305	.70441	072	.28376	846	.22204	7
573	.6645	334	.67680	101	.26355	876	.20661	6
.08602	11.6248	.10363	9.64935	.12131	8.24345	.13906	7.19125	5
632	.5853	393	.62205	160	.22344	935	.17594	4
661	.5461	422	.59490	190	.20352	965	.16071	3
690	.5072	452	.56791	219	.18370	995	.14553	2
720	.4685	481	.54106	249	.16398	.14024	.13042	1
.08749	11.4301	.10510	9.51436	.12278	8.14435	.14054	7.11537	0
Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	M.
85°		84°		83°		82°		

M.	8°		9°		10°		
	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.
0	.14054	7.11537	.15838	6.31375	.17633	5.67128	.19438
1	084	.10038	868	.30189	663	.66165	468
2	113	.08546	898	.29007	693	.65205	498
3	143	.07059	928	.27829	723	.64248	529
4	173	.05579	958	.26655	753	.63295	559
5	.14202	7.04105	.15988	6.25486	.17783	5.62344	.19589
6	232	.02637	.16017	.24321	813	.61397	619
7	262	.01174	047	.23160	843	.60452	649
8	291	6.99718	077	.22003	873	.59511	680
9	321	.98268	107	.20851	903	.58573	710
10	.14351	6.96823	.16137	6.19703	.17933	5.57638	.19740
11	381	.95385	167	.18559	963	.56706	770
12	410	.93952	196	.17419	993	.55777	801
13	440	.92525	226	.16283	.18023	.54851	831
14	470	.91104	256	.15151	053	.53927	861
15	.14499	6.89688	.16286	6.14023	.18083	5.53007	.19891
16	529	.88278	316	.12899	113	.52090	921
17	559	.86874	346	.11779	143	.51176	952
18	588	.85475	376	.10664	173	.50264	982
19	618	.84082	405	.09552	203	.49356	.20012
20	.14648	6.82694	.16435	6.08444	.18233	5.48451	.20042
21	678	.81312	465	.07340	263	.47548	073
22	707	.79936	495	.06240	293	.46648	103
23	737	.78564	525	.05143	323	.45751	133
24	767	.77199	555	.04051	353	.44857	164
25	.14796	6.75838	.16585	6.02962	.18384	5.43966	.20194
26	826	.74483	615	.01878	414	.43077	224
27	856	.73133	645	.00797	444	.42192	254
28	886	.71789	674	5.99720	474	.41309	285
29	915	.70450	704	.98646	504	.40429	315
30	.14945	6.69116	.16734	5.97576	.18534	5.39552	.20345
31	975	.67787	764	.96510	564	.38677	376
32	.15005	.66463	794	.95448	594	.37805	406
33	034	.65144	824	.94390	624	.36936	436
34	064	.63831	854	.93335	654	.36070	466
35	.15094	6.62523	.16884	5.92283	.18684	5.35206	.20497
36	124	.61219	914	.91236	714	.34345	527
37	153	.59921	944	.90191	745	.33487	557
38	183	.58627	974	.89151	775	.32631	588
39	213	.57339	.17004	.88114	805	.31778	618
40	.15243	6.56055	.17033	5.87080	.18835	5.30928	.20648
41	272	.54777	063	.86051	865	.30080	679
42	302	.53503	093	.85024	895	.29235	709
43	332	.52234	123	.84001	925	.28393	739
44	362	.50970	153	.82982	955	.27553	770
45	.15391	6.49710	.17183	5.81966	.18986	5.26715	.20800
46	421	.48456	213	.80953	.19016	.25880	830
47	451	.47206	243	.79944	046	.25048	861
48	481	.45961	273	.78938	076	.24218	891
49	511	.44720	303	.77936	106	.23391	921
50	.15540	6.43484	.17333	5.76937	.19136	5.22566	.20952
51	570	.42253	363	.75941	166	.21744	982
52	600	.41026	393	.74949	197	.20925	.21013
53	630	.39804	423	.73960	227	.20107	043
54	660	.38587	453	.72974	257	.19293	073
55	.15689	6.37374	.17483	5.71992	.19287	5.18480	.21104
56	719	.36165	513	.71013	317	.17671	134
57	749	.34961	543	.70037	347	.16863	164
58	779	.33761	573	.69064	378	.16058	195
59	809	.32566	603	.68094	408	.15256	225
60	.15838	6.31375	.17633	5.67128	.19438	5.14455	.21256
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot
	81°		80°		79°		

M.	12° Tan.	12° Cot.	13° Tan.	13° Cot.	14° Tan.	14° Cot.	15° Tan.	15° Cot.	
0	.21256	4.70463	.23087	4.33148	.24933	4.01078	.26795	3.73205	60
1	286	.69791	117	.32573	964	.00582	826	.72771	59
2	316	.69121	148	.32001	995	.00086	857	.72338	58
3	347	.68452	179	.31430	.25026	3.99592	888	.71907	57
4	377	.67786	209	.30860	056	.99099	920	.71476	56
5	.21408	4.67121	.23240	4.30291	.25087	3.98607	.26951	3.71046	55
6	438	.66458	271	.29724	118	.98117	982	.70616	54
7	469	.65797	301	.29159	149	.97627	.27013	.70188	53
8	499	.65138	332	.28595	180	.97139	044	.69761	52
9	529	.64480	363	.28032	211	.96651	076	.69335	51
10	.21560	4.63825	.23393	4.27471	.25242	3.96165	.27107	3.68909	50
11	590	.63171	424	.26911	273	.95680	138	.68485	49
12	621	.62518	455	.26352	304	.95196	169	.68061	48
13	651	.61868	485	.25795	335	.94713	201	.67638	47
14	682	.61219	516	.25239	366	.94232	232	.67217	46
15	.21712	4.60572	.23547	4.24685	.25397	3.93751	.27263	3.66796	45
16	743	.59927	578	.24132	428	.93271	294	.66376	44
17	773	.59283	608	.23580	459	.92793	326	.65957	43
18	804	.58641	639	.23030	490	.92316	357	.65538	42
19	834	.58001	670	.22481	521	.91839	388	.65121	41
20	.21864	4.57363	.23700	4.21933	.25552	3.91364	.27419	3.64705	40
21	895	.56726	731	.21387	583	.90890	451	.64289	39
22	925	.56091	762	.20842	614	.90417	482	.63874	38
23	956	.55458	793	.20298	645	.89945	513	.63461	37
24	986	.54826	823	.19756	676	.89474	545	.63048	36
25	.22017	4.54196	.23854	4.19215	.25707	3.89004	.27576	3.62636	35
26	047	.53568	885	.18675	738	.88536	607	.62224	34
27	078	.52941	916	.18137	769	.88068	638	.61814	33
28	108	.52316	946	.17600	800	.87601	670	.61405	32
29	139	.51693	977	.17064	831	.87136	701	.60996	31
30	.22169	4.51071	.24008	4.16530	.25862	3.86671	.27732	3.60588	30
31	200	.50451	039	.15997	893	.86208	764	.60181	29
32	231	.49832	069	.15465	924	.85745	795	.59775	28
33	261	.49215	100	.14934	955	.85284	826	.59370	27
34	292	.48600	131	.14405	986	.84824	858	.58966	26
35	.22322	4.47986	.24162	4.13877	.26017	3.84364	.27889	3.58562	25
36	353	.47374	193	.13350	048	.83906	921	.58160	24
37	383	.46764	223	.12825	079	.83449	952	.57758	23
38	414	.46155	254	.12301	110	.82992	983	.57357	22
39	444	.45548	285	.11778	141	.82537	.28015	.56957	21
40	.22475	4.44942	.24316	4.11256	.26172	3.82083	.28046	3.56557	20
41	505	.44338	347	.10736	203	.81630	077	.56159	19
42	536	.43735	377	.10216	235	.81177	109	.55761	18
43	567	.43134	408	.09699	266	.80726	140	.55364	17
44	597	.42534	439	.09182	297	.80276	172	.54968	16
45	.22628	4.41936	.24470	4.08666	.26328	3.79827	.28203	3.54573	15
46	658	.41340	501	.08152	359	.79378	234	.54179	14
47	689	.40745	532	.07639	390	.78931	266	.53785	13
48	719	.40152	562	.07127	421	.78485	297	.53393	12
49	750	.39560	593	.06616	452	.78040	329	.53001	11
50	.22781	4.38969	.24624	4.06107	.26483	3.77595	.28360	3.52609	10
51	811	.38381	655	.05599	515	.77152	391	.52219	9
52	842	.37793	686	.05092	546	.76709	423	.51829	8
53	872	.37207	717	.04586	577	.76268	454	.51441	7
54	903	.36623	747	.04081	608	.75828	486	.51053	6
55	.22934	4.36040	.24778	4.03578	.26639	3.75388	.28517	3.50666	5
56	964	.35459	809	.03076	670	.74950	549	.50279	4
57	995	.34879	840	.02574	701	.74512	580	.49894	3
58	.23026	.34300	871	.02074	733	.74075	612	.49509	2
59	056	.33723	902	.01576	764	.73640	643	.49125	1
60	.23087	4.33148	.24933	4.01078	.26795	3.73205	.28675	3.48741	0
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	M.
	77°		76°		75°		74°		

M.	8°		9°		10°		I
	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.
0	.14054	7.11537	.15838	6.31375	.17633	5.67128	.19438
1	084	.10038	868	.30189	663	.66165	468
2	113	.08546	898	.29007	693	.65205	498
3	143	.07059	928	.27829	723	.64248	529
4	173	.05579	958	.26655	753	.63295	559
5	.14202	7.04105	.15988	6.25486	.17783	5.62344	.19589
6	232	.02637	.16017	.24321	813	.61397	619
7	262	.01174	047	.23160	843	.60452	649
8	291	6.99718	077	.22003	873	.59511	680
9	321	.98268	107	.20851	903	.58573	710
10	.14351	6.96823	.16137	6.19703	.17933	5.57638	.19740
11	381	.95385	167	.18559	963	.56706	770
12	410	.93952	196	.17419	993	.55777	801
13	440	.92525	226	.16283	.18023	.54851	831
14	470	.91104	256	.15151	053	.53927	861
15	.14499	6.89688	.16286	6.14023	.18083	5.53007	.19891
16	529	.88278	316	.12899	113	.52090	921
17	559	.86874	346	.11779	143	.51176	952
18	588	.85475	376	.10664	173	.50264	982
19	618	.84082	405	.09552	203	.49356	.20012
20	.14648	6.82694	.16435	6.08444	.18233	5.48451	.20042
21	678	.81312	465	.07340	263	.47548	073
22	707	.79936	495	.06240	293	.46648	103
23	737	.78564	525	.05143	323	.45751	133
24	767	.77199	555	.04051	353	.44857	164
25	.14796	6.75838	.16585	6.02962	.18384	5.43966	.20194
26	826	.74483	615	.01878	414	.43077	224
27	856	.73133	645	.00797	444	.42192	254
28	886	.71789	674	5.99720	474	.41309	285
29	915	.70450	704	.98646	504	.40429	315
30	.14945	6.69116	.16734	5.97576	.18534	5.39552	.20345
31	975	.67787	764	.96510	564	.38677	376
32	.15005	.66463	794	.95448	594	.37805	406
33	034	.65144	824	.94390	624	.36936	436
34	064	.63831	854	.93335	654	.36070	466
35	.15094	6.62523	.16884	5.92283	.18684	5.35206	.20497
36	124	.61219	914	.91236	714	.34345	527
37	153	.59921	944	.90191	745	.33487	557
38	183	.58627	974	.89151	775	.32631	588
39	213	.57339	.17004	.88114	805	.31778	618
40	.15243	6.56055	.17033	5.87080	.18835	5.30928	.20648
41	272	.54777	063	.86051	865	.30080	679
42	302	.53503	093	.85024	895	.29235	709
43	332	.52234	123	.84001	925	.28393	739
44	362	.50970	153	.82982	955	.27553	770
45	.15391	6.49710	.17183	5.81966	.18986	5.26715	.20800
46	421	.48456	213	.80953	.19016	.25880	830
47	451	.47206	243	.79944	046	.25048	861
48	481	.45961	273	.78938	076	.24218	891
49	511	.44720	303	.77936	106	.23391	921
50	.15540	6.43484	.17333	5.76937	.19136	5.22566	.20952
51	570	.42253	363	.75941	166	.21744	982
52	600	.41026	393	.74949	197	.20925	.21013
53	630	.39804	423	.73960	227	.20107	043
54	660	.38587	453	.72974	257	.19293	073
55	.15689	6.37374	.17483	5.71992	.19287	5.18480	.21104
56	719	.36165	513	.71013	317	.17671	134
57	749	.34961	543	.70037	347	.16863	164
58	779	.33761	573	.69064	378	.16058	195
59	809	.32566	603	.68094	408	.15256	225
60	.15838	6.31375	.17633	5.67128	.19438	5.14455	.21256
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.
	81°		80°		79°		

20°		21°		22°		23°		
Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	
.36397	2.74748	.38386	2.60509	.40403	2.47509	.42447	2.35585	60
430	.74499	420	.60283	436	.47302	482	.35395	59
463	.74251	453	.60057	470	.47095	516	.35205	58
496	.74004	487	.59831	504	.46888	551	.35015	57
529	.73756	520	.59606	538	.46682	585	.34825	56
.36562	2.73509	.38553	2.59381	.40572	2.46476	.42619	2.34636	55
595	.73263	587	.59156	606	.46270	654	.34447	54
628	.73017	620	.58932	640	.46065	688	.34258	53
661	.72771	654	.58708	674	.45860	722	.34069	52
694	.72526	687	.58484	707	.45655	757	.33881	51
.36727	2.72281	.38721	2.58261	.40741	2.45451	.42791	2.33693	50
760	.72036	754	.58038	775	.45246	826	.33505	49
793	.71792	787	.57815	809	.45043	860	.33317	48
826	.71548	821	.57593	843	.44839	894	.33130	47
859	.71305	854	.57371	877	.44636	929	.32943	46
.36892	2.71062	.38888	2.57150	.40911	2.44433	.42963	2.32756	45
925	.70819	921	.56928	945	.44230	998	.32570	44
958	.70577	955	.56707	979	.44027	.43032	.32383	43
991	.70335	988	.56487	.41013	.43825	067	.32197	42
.37024	.70094	.39022	.56266	047	.43623	101	.32012	41
.37057	2.69853	.39055	2.56046	.41081	2.43422	.43136	2.31826	40
090	.69612	089	.55827	115	.43220	170	.31641	39
123	.69371	122	.55608	149	.43019	205	.31456	38
157	.69131	156	.55389	183	.42819	239	.31271	37
190	.68892	190	.55170	217	.42618	274	.31086	36
.37223	2.68653	.39223	2.54952	.41251	2.42418	.43308	2.30902	35
256	.68414	257	.54734	285	.42218	343	.30718	34
289	.68175	290	.54516	319	.42019	378	.30534	33
322	.67937	324	.54299	353	.41819	412	.30351	32
355	.67700	357	.54082	387	.41620	447	.30167	31
.37388	2.67462	.39391	2.53865	.41421	2.41421	.43481	2.29984	30
422	.67225	425	.53648	455	.41223	516	.29801	29
455	.66989	458	.53432	490	.41025	550	.29619	28
488	.66752	492	.53217	524	.40827	585	.29437	27
521	.66516	526	.53001	558	.40629	620	.29254	26
.37554	2.66281	.39559	2.52786	.41592	2.40432	.43654	2.29073	25
588	.66046	593	.52571	626	.40235	689	.28891	24
621	.65811	626	.52357	660	.40038	724	.28710	23
654	.65576	660	.52142	694	.39841	758	.28528	22
687	.65342	694	.51929	728	.39645	793	.28348	21
.37720	2.65109	.39727	2.51715	.41763	2.39449	.43828	2.28167	20
754	.64875	761	.51502	797	.39253	862	.27987	19
787	.64642	795	.51289	831	.39058	897	.27806	18
820	.64410	829	.51076	865	.38863	932	.27626	17
853	.64177	862	.50864	899	.38668	966	.27447	16
.37887	2.63945	.39896	2.50652	.41933	2.38473	.44001	2.27267	15
920	.63714	930	.50440	968	.38279	036	.27088	14
953	.63483	963	.50229	.42002	.38084	071	.26909	13
986	.63252	997	.50018	036	.37891	105	.26730	12
.38020	.63021	.40031	.49807	070	.37697	140	.26552	11
.38053	2.62791	.40065	2.49597	.42105	2.37504	.44175	2.26374	10
086	.62561	098	.49386	139	.37311	210	.26196	9
120	.62332	132	.49177	173	.37118	244	.26018	8
153	.62103	166	.48967	207	.36925	279	.25840	7
186	.61874	200	.48758	242	.36733	314	.25663	6
.38220	2.61646	.40234	2.48549	.42276	2.36541	.44349	2.25486	5
253	.61418	267	.48340	310	.36349	384	.25309	4
286	.61190	301	.48132	345	.36158	418	.25132	3
320	.60963	335	.47924	379	.35967	453	.24956	2
353	.60736	369	.47716	413	.35776	488	.24780	1
.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	0
Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	M.
69°		68°		67°		66°		

M.	16°		17°		18°		I
	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.
0	.28675	3.46741	.30573	3.27085	.32492	3.07768	.34433
1	706	.48359	605	.26745	524	.07464	465
2	738	.47977	637	.26406	556	.07160	498
3	769	.47596	669	.26067	588	.06857	530
4	801	.47216	700	.25729	621	.06554	563
5	.28832	3.46837	.30732	3.25392	.32653	3.06252	.34596
6	864	.46458	764	.25055	685	.05950	628
7	895	.46080	796	.24719	717	.05649	661
8	927	.45703	828	.24383	749	.05349	693
9	958	.45327	860	.24049	782	.05049	726
10	.28990	3.44951	.30891	3.23714	.32814	3.04749	.34758
11	.29021	.44576	923	.23381	846	.04450	791
12	053	.44202	955	.23048	878	.04152	824
13	084	.43829	987	.22715	911	.03854	856
14	116	.43456	.31019	.22384	943	.03556	889
15	.29147	3.43084	.31051	3.22053	.32975	3.03260	.34922
16	179	.42713	083	.21722	.33007	.02963	954
17	210	.42343	115	.21392	040	.02667	987
18	242	.41973	147	.21063	072	.02372	.35020
19	274	.41604	178	.20734	104	.02077	052
20	.29305	3.41236	.31210	3.20406	.33136	3.01783	.35085
21	337	.40869	242	.20079	169	.01489	118
22	368	.40502	274	.19752	201	.01196	150
23	400	.40136	306	.19426	233	.00903	183
24	432	.39771	338	.19100	266	.00611	216
25	.29463	3.39406	.31370	3.18775	.33298	3.00319	.35248
26	495	.39042	402	.18451	330	.00028	281
27	526	.38679	434	.18127	363	2.99738	314
28	558	.38317	466	.17804	395	.99447	346
29	590	.37955	498	.17481	427	.99158	379
30	.29621	3.37594	.31530	3.17159	.33460	2.98868	.35412
31	653	.37234	562	.16838	492	.98580	445
32	685	.36875	594	.16517	524	.98292	477
33	716	.36516	626	.16197	557	.98004	510
34	748	.36158	658	.15877	589	.97717	543
35	.29780	3.35800	.31690	3.15558	.33621	2.97430	.35576
36	811	.35443	722	.15240	654	.97144	608
37	843	.35087	754	.14922	686	.96858	641
38	875	.34732	786	.14605	718	.96573	674
39	906	.34377	818	.14288	751	.96288	707
40	.29938	3.34023	.31850	3.13972	.33783	2.96004	.35740
41	970	.33670	882	.13656	816	.95721	772
42	.30001	.33317	914	.13341	848	.95437	805
43	033	.32965	946	.13027	881	.95155	838
44	065	.32614	978	.12713	913	.94872	871
45	.30097	3.32264	.32010	3.12400	.33945	2.94591	.35904
46	128	.31914	042	.12087	978	.94309	937
47	160	.31565	074	.11775	.34010	.94028	969
48	192	.31216	106	.11464	043	.93748	.36002
49	224	.30868	139	.11153	075	.93468	035
50	.30255	3.30521	.32171	3.10842	.34108	2.93189	.36068
51	287	.30174	203	.10532	140	.92910	101
52	319	.29829	235	.10223	173	.92632	134
53	351	.29483	267	.09914	205	.92354	167
54	382	.29139	299	.09606	238	.92076	199
55	.30414	3.28795	.32331	3.09298	.34270	2.91799	.36232
56	446	.28452	363	.08991	303	.91523	265
57	478	.28109	396	.08685	335	.91246	298
58	509	.27767	428	.08379	368	.90971	331
59	541	.27426	460	.08073	400	.90696	364
60	.30573	3.27085	.32492	3.07768	.34433	2.90421	.36397
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot
	73°		72°		71°		

20°		21°		22°		23°		
Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	
.36397	2.74748	.38386	2.60509	.40403	2.47509	.42447	2.35585	60
430	.74499	420	.60283	436	.47302	482	.35395	59
463	.74251	453	.60057	470	.47095	516	.35205	58
496	.74004	487	.59831	504	.46888	551	.35015	57
529	.73756	520	.59606	538	.46682	585	.34825	56
.36562	2.73509	.38553	2.59381	.40572	2.46476	.42619	2.34636	55
595	.73263	587	.59156	606	.46270	654	.34447	54
628	.73017	620	.58932	640	.46065	688	.34258	53
661	.72771	654	.58708	674	.45860	722	.34069	52
694	.72526	687	.58484	707	.45655	757	.33881	51
.36727	2.72281	.38721	2.58261	.40741	2.45451	.42791	2.33693	50
760	.72036	754	.58038	775	.45246	826	.33505	49
793	.71792	787	.57815	809	.45043	860	.33317	48
826	.71548	821	.57593	843	.44839	894	.33130	47
859	.71305	854	.57371	877	.44636	929	.32943	46
.36892	2.71062	.38888	2.57150	.40911	2.44433	.42963	2.32756	45
925	.70819	921	.56928	945	.44230	998	.32570	44
958	.70577	955	.56707	979	.44027	.43032	.32383	43
991	.70335	988	.56487	.41013	.43825	067	.32197	42
.37024	.70094	.39022	.56266	047	.43623	101	.32012	41
.37057	2.69853	.39055	2.56046	.41081	2.43422	.43136	2.31826	40
090	.69612	089	.55827	115	.43220	170	.31641	39
123	.69371	122	.55608	149	.43019	205	.31456	38
157	.69131	156	.55389	183	.42819	239	.31271	37
190	.68892	190	.55170	217	.42618	274	.31086	36
.37223	2.68653	.39223	2.54952	.41251	2.42418	.43308	2.30902	35
256	.68414	257	.54734	285	.42218	343	.30718	34
289	.68175	290	.54516	319	.42019	378	.30534	33
322	.67937	324	.54299	353	.41819	412	.30351	32
355	.67700	357	.54082	387	.41620	447	.30167	31
.37388	2.67462	.39391	2.53865	.41421	2.41421	.43481	2.29984	30
422	.67225	425	.53648	455	.41223	516	.29801	29
455	.66989	458	.53432	490	.41025	550	.29619	28
488	.66752	492	.53217	524	.40827	585	.29437	27
521	.66516	526	.53001	558	.40629	620	.29254	26
.37554	2.66281	.39559	2.52786	.41592	2.40432	.43654	2.29073	25
588	.66046	593	.52571	626	.40235	689	.28891	24
621	.65811	626	.52357	660	.40038	724	.28710	23
654	.65576	660	.52142	694	.39841	758	.28528	22
687	.65342	694	.51929	728	.39645	793	.28348	21
.37720	2.65109	.39727	2.51715	.41763	2.39449	.43828	2.28167	20
754	.64875	761	.51502	797	.39253	862	.27987	19
787	.64642	795	.51289	831	.39058	897	.27806	18
820	.64410	829	.51076	865	.38863	932	.27626	17
853	.64177	862	.50864	899	.38668	966	.27447	16
.37887	2.63945	.39896	2.50652	.41933	2.38473	.44001	2.27267	15
920	.63714	930	.50440	968	.38279	036	.27088	14
953	.63483	963	.50229	.42002	.38084	071	.26909	13
986	.63252	997	.50018	036	.37891	105	.26730	12
.38020	.63021	.40031	.49807	070	.37697	140	.26552	11
.38053	2.62791	.40065	2.49597	.42105	2.37504	.44175	2.26374	10
086	.62561	098	.49386	139	.37311	210	.26196	9
120	.62332	132	.49177	173	.37118	244	.26018	8
153	.62103	166	.48967	207	.36925	279	.25840	7
186	.61874	200	.48758	242	.36733	314	.25663	6
.38220	2.61646	.40234	2.48549	.42276	2.36541	.44349	2.25486	5
253	.61418	267	.48340	310	.36349	384	.25309	4
286	.61190	301	.48132	345	.36158	418	.25132	3
320	.60963	335	.47924	379	.35967	453	.24956	2
353	.60736	369	.47716	413	.35776	488	.24780	1
.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	0
Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	M
69°		68°		67°		66°		

M.	32° Tan.	32° Cot.	33° Tan.	33° Cot.	34° Tan.	34° Cot.	35° Tan.	35° Cot.	
0	.62487	1.60033	.64941	1.53986	.67451	1.48256	.70021	1.42815	60
1	527	.59930	982	.53888	493	.48163	064	.42726	59
2	568	.59826	.65024	.53791	536	.48070	107	.42638	58
3	608	.59723	065	.53693	578	.47977	151	.42550	57
4	649	.59620	106	.53595	620	.47885	194	.42462	56
5	.62689	1.59517	.65148	1.53497	.67663	1.47792	.70238	1.42374	55
6	730	.59414	189	.53400	705	.47699	281	.42286	54
7	770	.59311	231	.53302	748	.47607	325	.42198	53
8	811	.59208	272	.53205	790	.47514	368	.42110	52
9	852	.59105	314	.53107	832	.47422	412	.42022	51
10	.62892	1.59002	.65355	1.53010	.67875	1.47330	.70455	1.41934	50
11	933	.58900	397	.52913	917	.47238	499	.41847	49
12	973	.58797	438	.52816	960	.47146	542	.41759	48
13	.63014	.58695	480	.52719	.68002	.47053	586	.41672	47
14	055	.58593	521	.52622	045	.46962	629	.41584	46
15	.63095	1.58490	.65563	1.52525	.68088	1.46870	.70673	1.41497	45
16	136	.58388	604	.52429	130	.46778	717	.41409	44
17	177	.58286	646	.52332	173	.46686	760	.41322	43
18	217	.58184	688	.52235	215	.46595	804	.41235	42
19	258	.58083	729	.52139	258	.46503	848	.41148	41
20	.63299	1.57981	.65771	1.52043	.68301	1.46411	.70891	1.41061	40
21	340	.57879	813	.51946	343	.46320	935	.40974	39
22	380	.57778	854	.51850	386	.46229	979	.40887	38
23	421	.57676	896	.51754	429	.46137	.71023	.40800	37
24	462	.57575	938	.51658	471	.46046	066	.40714	36
25	.63503	1.57474	.65980	1.51562	.68514	1.45955	.71110	1.40627	35
26	544	.57372	.66021	.51466	557	.45864	154	.40540	34
27	584	.57271	063	.51370	600	.45773	198	.40454	33
28	625	.57170	105	.51275	642	.45682	242	.40367	32
29	666	.57069	147	.51179	685	.45592	285	.40281	31
30	.63707	1.56969	.66189	1.51084	.68728	1.45501	.71329	1.40195	30
31	748	.56868	230	.50988	771	.45410	373	.40109	29
32	789	.56767	272	.50893	814	.45320	417	.40022	28
33	830	.56667	314	.50797	857	.45229	461	.39936	27
34	871	.56566	356	.50702	900	.45139	505	.39850	26
35	.63912	1.56466	.66398	1.50607	.68942	1.45049	.71549	1.39764	25
36	953	.56366	440	.50512	985	.44958	593	.39679	24
37	994	.56265	482	.50417	.69028	.44868	637	.39593	23
38	.64035	.56165	524	.50322	071	.44778	681	.39507	22
39	076	.56065	566	.50228	114	.44688	725	.39421	21
40	.64117	1.55966	.66608	1.50133	.69157	1.44598	.71769	1.39336	20
41	158	.55866	650	.50038	200	.44508	813	.39250	19
42	199	.55766	692	.49944	243	.44418	857	.39165	18
43	240	.55666	734	.49849	286	.44329	901	.39079	17
44	281	.55567	776	.49755	329	.44239	946	.38994	16
45	.64322	1.55467	.66818	1.49661	.69372	1.44149	.71990	1.38909	15
46	363	.55368	860	.49566	416	.44060	.72034	.38824	14
47	404	.55269	902	.49472	459	.43970	078	.38738	13
48	446	.55170	944	.49378	502	.43881	122	.38653	12
49	487	.55071	986	.49284	545	.43792	167	.38568	11
50	.64528	1.54972	.67028	1.49190	.69588	1.43703	.72211	1.38484	10
51	569	.54873	071	.49097	631	.43614	255	.38399	9
52	610	.54774	113	.49003	675	.43525	299	.38314	8
53	652	.54675	155	.48909	718	.43436	344	.38229	7
54	693	.54576	197	.48816	761	.43347	388	.38145	6
55	.64734	1.54478	.67239	1.48722	.69804	1.43258	.72432	1.38060	5
56	775	.54379	282	.48629	847	.43169	477	.37976	4
57	817	.54281	324	.48536	891	.43080	521	.37891	3
58	858	.54183	366	.48442	934	.42992	565	.37807	2
59	899	.54085	409	.48349	977	.42903	610	.37722	1
60	.64941	1.53986	.67451	1.48256	.70021	1.42815	.72654	1.37638	0
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	M.
	57°		56°		55°		54°		

6° Cot.	37° Tan.	37° Cot.	38° Tan.	38° Cot.	39° Tan.	39° Cot.	
1.37638	.75355	1.32704	.78129	1.27994	.80978	1.23490	60
.37554	401	.32624	175	.27917	.81027	.23416	59
.37470	447	.32544	222	.27841	075	.23343	58
.37386	492	.32464	269	.27764	123	.23270	57
.37302	538	.32384	316	.27688	171	.23196	56
1.37218	.75584	1.32304	.78363	1.27611	.81220	1.23123	55
.37134	629	.32224	410	.27535	268	.23050	54
.37050	675	.32144	457	.27458	316	.22977	53
.36967	721	.32064	504	.27382	364	.22904	52
.36883	767	.31984	551	.27306	413	.22831	51
1.36800	.75812	1.31904	.78598	1.27230	.81461	1.22758	50
.36716	858	.31825	645	.27153	510	.22685	49
.36633	904	.31745	692	.27077	558	.22612	48
.36549	950	.31666	739	.27001	606	.22539	47
.36466	996	.31586	786	.26925	655	.22467	46
1.36383	.76042	1.31507	.78834	1.26849	.81703	1.22394	45
.36300	088	.31427	881	.26774	752	.22321	44
.36217	134	.31348	928	.26698	800	.22249	43
.36134	180	.31269	975	.26622	849	.22176	42
.36051	226	.31190	.79022	.26546	898	.22104	41
1.35968	.76272	1.31110	.79070	1.26471	.81946	1.22031	40
.35885	318	.31031	117	.26395	995	.21959	39
.35802	364	.30952	164	.26319	.82044	.21886	38
.35719	410	.30873	212	.26244	092	.21814	37
.35637	456	.30795	259	.26169	141	.21742	36
1.35554	.76502	1.30716	.79306	1.26093	.82190	1.21670	35
.35472	548	.30637	354	.26018	238	.21598	34
.35389	594	.30558	401	.25943	287	.21526	33
.35307	640	.30480	449	.25867	336	.21454	32
.35224	686	.30401	496	.25792	385	.21382	31
1.35142	.76733	1.30323	.79544	1.25717	.82434	1.21310	30
.35060	779	.30244	591	.25642	483	.21238	29
.34978	825	.30166	639	.25567	531	.21166	28
.34896	871	.30087	686	.25492	580	.21094	27
.34814	918	.30009	734	.25417	629	.21023	26
1.34732	.76964	1.29931	.79781	1.25343	.82678	1.20951	25
.34650	.77010	.29853	829	.25268	727	.20879	24
.34568	057	.29775	877	.25193	776	.20808	23
.34487	103	.29696	924	.25118	825	.20736	22
.34405	149	.29618	972	.25044	874	.20665	21
1.34323	.77196	1.29541	.80020	1.24969	.82923	1.20593	20
.34242	242	.29463	067	.24895	972	.20522	19
.34160	289	.29385	115	.24820	.83022	.20451	18
.34079	335	.29307	163	.24746	071	.20379	17
.33998	382	.29229	211	.24672	120	.20308	16
1.33916	.77428	1.29152	.80258	1.24597	.83169	1.20237	15
.33835	475	.29074	306	.24523	218	.20166	14
.33754	521	.28997	354	.24449	268	.20095	13
.33673	568	.28919	402	.24375	317	.20024	12
.33592	615	.28842	450	.24301	366	.19953	11
1.33511	.77661	1.28764	.80498	1.24227	.83415	1.19882	10
.33430	708	.28687	546	.24153	465	.19811	9
.33349	754	.28610	594	.24079	514	.19740	8
.33268	801	.28533	642	.24005	564	.19669	7
.33187	848	.28456	690	.23931	613	.19599	6
1.33107	.77895	1.28379	.80738	1.23858	.83662	1.19528	5
.33026	941	.28302	786	.23784	712	.19457	4
.32946	988	.28225	834	.23710	761	.19387	3
.32865	.78035	.28148	882	.23637	811	.19316	2
.32785	082	.28071	930	.23563	860	.19246	1
1.32704	.78129	1.27994	.80978	1.23490	.83910	1.19175	0
Tan. 3°	Cot.	Tan. 52°	Cot.	Tan. 51°	Cot.	Tan. 50°	M.

M.	32°		33°		34°		35	
	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	
0	.62487	1.60033	.64941	1.53986	.67451	1.48256	.70021	1
1	527	.59930	982	.53888	493	.48163	064	.
2	568	.59826	.65024	.53791	536	.48070	107	.
3	608	.59723	065	.53693	578	.47977	151	.
4	649	.59620	106	.53595	620	.47885	194	.
5	.62689	1.59517	.65148	1.53497	.67663	1.47792	.70238	1.
6	730	.59414	189	.53400	705	.47699	281	.
7	770	.59311	231	.53302	748	.47607	325	.
8	811	.59208	272	.53205	790	.47514	368	.
9	852	.59105	314	.53107	832	.47422	412	.
10	.62892	1.59002	.65355	1.53010	.67875	1.47330	.70455	1.
11	933	.58900	397	.52913	917	.47238	499	.
12	973	.58797	438	.52816	960	.47146	542	.
13	.63014	.58695	480	.52719	.68002	.47053	586	.
14	055	.58593	521	.52622	045	.46962	629	.
15	.63095	1.58490	.65563	1.52525	.68088	1.46870	.70673	1.
16	136	.58388	604	.52429	130	.46778	717	.
17	177	.58286	646	.52332	173	.46686	760	.
18	217	.58184	688	.52235	215	.46595	804	.
19	258	.58083	729	.52139	258	.46503	848	.
20	.63299	1.57981	.65771	1.52043	.68301	1.46411	.70891	1.
21	340	.57879	813	.51946	343	.46320	935	.
22	380	.57778	854	.51850	386	.46229	979	.
23	421	.57676	896	.51754	429	.46137	.71023	.
24	462	.57575	938	.51658	471	.46046	066	.
25	.63503	1.57474	.65980	1.51562	.68514	1.45955	.71110	1.
26	544	.57372	.66021	.51466	557	.45864	154	.
27	584	.57271	063	.51370	600	.45773	198	.
28	625	.57170	105	.51275	642	.45682	242	.
29	666	.57069	147	.51179	685	.45592	285	.
30	.63707	1.56969	.66189	1.51084	.68728	1.45501	.71329	1.
31	748	.56868	230	.50988	771	.45410	373	.
32	789	.56767	272	.50893	814	.45320	417	.
33	830	.56667	314	.50797	857	.45229	461	.
34	871	.56566	356	.50702	900	.45139	505	.
35	.63912	1.56466	.66398	1.50607	.68942	1.45049	.71549	1.
36	953	.56366	440	.50512	985	.44958	593	.
37	994	.56265	482	.50417	.69028	.44868	637	.
38	.64035	.56165	524	.50322	071	.44778	681	.
39	076	.56065	566	.50228	114	.44688	725	.
40	.64117	1.55966	.66608	1.50133	.69157	1.44598	.71769	1.
41	158	.55866	650	.50038	200	.44508	813	.
42	199	.55766	692	.49944	243	.44418	857	.
43	240	.55666	734	.49849	286	.44329	901	.
44	281	.55567	776	.49755	329	.44239	946	.
45	.64322	1.55467	.66818	1.49661	.69372	1.44149	.71990	1.
46	363	.55368	860	.49566	416	.44060	.72034	.
47	404	.55269	902	.49472	459	.43970	078	.
48	446	.55170	944	.49378	502	.43881	122	.
49	487	.55071	986	.49284	545	.43792	167	.
50	.64528	1.54972	.67028	1.49190	.69588	1.43703	.72211	1.
51	569	.54873	071	.49097	631	.43614	255	.
52	610	.54774	113	.49003	675	.43525	299	.
53	652	.54675	155	.48909	718	.43436	344	.
54	693	.54576	197	.48816	761	.43347	388	.
55	.64734	1.54478	.67239	1.48722	.69804	1.43258	.72432	1.
56	775	.54379	282	.48629	847	.43169	477	.
57	817	.54281	324	.48536	891	.43080	521	.
58	858	.54183	366	.48442	934	.42992	565	.
59	899	.54085	409	.48349	977	.42903	610	
60	.64941	1.53986	.67451	1.48256	.70021	1.42815	.72654	
	Cot.	Tan.	Cot.	Tan.	Cot.	Tan.	Cot.	
	57°		56°		55°			

M.	44° Tan.	44° Cot.		M.	44° Tan.	44° Cot.		M.	44° Tan.	44° Cot.	
0	.96569	1.03553	60	20	.97700	1.02355	40	40	.98843	1.01170	20
1	625	.03493	59	21	756	.02295	39	41	901	.01112	19
2	681	.03433	58	22	813	.02236	38	42	958	.01053	18
3	738	.03372	57	23	870	.02176	37	43	.99016	.00994	17
4	794	.03312	56	24	927	.02117	36	44	073	.00935	16
5	.96850	1.03252	55	25	.97984	1.02057	35	45	.99131	1.00876	15
6	907	.03192	54	26	.98041	.01998	34	46	189	.00818	14
7	963	.03132	53	27	098	.01939	33	47	247	.00759	13
8	.97020	.03072	52	28	155	.01879	32	48	304	.00701	12
9	076	.03012	51	29	213	.01820	31	49	362	.00642	11
10	.97133	1.02952	50	30	.98270	1.01761	30	50	.99420	1.00583	10
11	189	.02892	49	31	327	.01702	29	51	478	.00525	9
12	246	.02832	48	32	384	.01642	28	52	536	.00467	8
13	302	.02772	47	33	441	.01583	27	53	594	.00408	7
14	359	.02713	46	34	499	.01524	26	54	652	.00350	6
15	.97416	1.02653	45	35	.98556	1.01465	25	55	.99710	1.00291	5
16	472	.02593	44	36	613	.01406	24	56	768	.00233	4
17	529	.02533	43	37	671	.01347	23	57	826	.00175	3
18	586	.02474	42	38	728	.01288	22	58	884	.00116	2
19	643	.02414	41	39	786	.01229	21	59	942	.00058	1
20	.97700	1.02355	40	40	.98843	1.01170	20	60	1.00000	1.00000	0
	Cot.	Tan.			Cot.	Tan.			Cot.	Tan.	
	45°		M.		45°		M.		45°		M.

M.	0°		1°		2°		3°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.
0	.00000	.00000	.00015	.00015	.00061	.00061	.00137	.00137
1	000	000	016	016	062	062	139	139
2	000	000	016	016	063	063	140	140
3	000	000	017	017	064	064	142	142
4	000	000	017	017	065	065	143	143
5	.00000	.00000	.00018	.00018	.00066	.00066	.00145	.00145
6	000	000	018	018	067	067	146	147
7	000	000	019	019	068	068	148	148
8	000	000	020	020	069	069	149	150
9	000	000	020	020	070	070	151	151
10	.00000	.00000	.00021	.00021	.00071	.00072	.00153	.00153
11	001	001	021	021	073	073	154	155
12	001	001	022	022	074	074	156	156
13	001	001	023	023	075	075	158	158
14	001	001	023	023	076	076	159	159
15	.00001	.00001	.00024	.00024	.00077	.00077	.00161	.00161
16	001	001	024	024	078	078	162	163
17	001	001	025	025	079	079	164	164
18	001	001	026	026	081	081	166	166
19	002	002	026	026	082	082	167	168
20	.00002	.00002	.00027	.00027	.00083	.00083	.00169	.00169
21	002	002	028	028	084	084	171	171
22	002	002	028	028	085	085	173	173
23	002	002	029	029	087	087	174	175
24	002	002	030	030	088	088	176	176
25	.00003	.00003	.00031	.00031	.00089	.00089	.00178	.00178
26	003	003	031	031	090	090	179	180
27	003	003	032	032	091	091	181	181
28	003	003	033	033	093	093	183	183
29	004	004	034	034	094	094	185	185
30	.00004	.00004	.00034	.00034	.00095	.00095	.00187	.00187
31	004	004	035	035	096	097	188	189
32	004	004	036	036	098	098	190	190
33	005	005	037	037	099	099	192	192
34	005	005	037	037	100	100	194	194
35	.00005	.00005	.00038	.00038	.00102	.00102	.00196	.00196
36	005	005	039	039	103	103	197	198
37	006	006	040	040	104	104	199	200
38	006	006	041	041	106	106	201	201
39	006	006	041	041	107	107	203	203
40	.00007	.00007	.00042	.00042	.00108	.00108	.00205	.00205
41	007	007	043	043	110	110	207	207
42	007	007	044	044	111	111	208	209
43	008	008	045	045	112	113	210	211
44	008	008	046	046	114	114	212	213
45	.00009	.00009	.00047	.00047	.00115	.00115	.00214	.00215
46	009	009	048	048	117	117	216	216
47	009	009	048	048	118	118	218	218
48	010	010	049	049	119	120	220	220
49	010	010	050	050	121	121	222	222
50	.00011	.00011	.00051	.00051	.00122	.00122	.00224	.00224
51	011	011	052	052	124	124	226	226
52	011	011	053	053	125	125	228	228
53	012	012	054	054	127	127	230	230
54	012	012	055	055	128	128	232	232
55	.00013	.00013	.00056	.00056	.00130	.00130	.00234	.00234
56	013	013	057	057	131	131	236	236
57	014	014	058	058	133	133	238	238
58	014	014	059	059	134	134	240	240
59	015	015	060	060	136	136	242	242
60	.00015	.00015	.00061	.00061	.00137	.00137	.00244	.00244

M.	4°		5°		6°		7°		M.
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
0	.00244	.00244	.00381	.00382	.00548	.00551	.00745	.00751	0
1	246	246	383	385	551	554	749	755	1
2	248	248	386	387	554	557	752	758	2
3	250	250	388	390	557	560	756	762	3
4	252	252	391	392	560	563	760	765	4
5	.00254	.00254	.00393	.00395	.00563	.00566	.00763	.00769	5
6	256	257	396	397	566	569	767	773	6
7	258	259	398	400	569	573	770	776	7
8	260	261	401	403	572	576	774	780	8
9	262	263	404	405	576	579	778	784	9
10	.00264	.00265	.00406	.00408	.00579	.00582	.00781	.00787	10
11	266	267	409	411	582	585	785	791	11
12	269	269	412	413	585	588	789	795	12
13	271	271	414	416	588	592	792	799	13
14	273	274	417	419	591	595	796	802	14
15	.00275	.00276	.00420	.00421	.00594	.00598	.00800	.00806	15
16	277	278	422	424	598	601	803	810	16
17	279	280	425	427	601	604	807	813	17
18	281	282	428	429	604	608	811	817	18
19	284	284	430	432	607	611	814	821	19
20	.00286	.00287	.00433	.00435	.00610	.00614	.00818	.00825	20
21	288	289	436	438	614	617	822	828	21
22	290	291	438	440	617	621	825	832	22
23	292	293	441	443	620	624	829	836	23
24	295	296	444	446	623	627	833	840	24
25	.00297	.00298	.00447	.00449	.00626	.00630	.00837	.00844	25
26	299	300	449	451	630	634	840	848	26
27	301	302	452	454	633	637	844	851	27
28	304	305	455	457	636	640	848	855	28
29	306	307	458	460	640	644	852	859	29
30	.00308	.00309	.00460	.00463	.00643	.00647	.00856	.00863	30
31	311	312	463	465	646	650	859	867	31
32	313	314	466	468	649	654	863	871	32
33	315	316	469	471	653	657	867	875	33
34	317	318	472	474	656	660	871	878	34
35	.00320	.00321	.00474	.00477	.00659	.00664	.00875	.00882	35
36	322	323	477	480	663	667	878	886	36
37	324	326	480	482	666	671	882	890	37
38	327	328	483	485	669	674	886	894	38
39	329	330	486	488	673	677	890	898	39
40	.00332	.00333	.00489	.00491	.00676	.00681	.00894	.00902	40
41	334	335	492	494	680	684	898	906	41
42	336	337	494	497	683	688	902	910	42
43	339	340	497	500	686	691	906	914	43
44	341	342	500	503	690	695	909	918	44
45	.00343	.00345	.00503	.00506	.00693	.00698	.00913	.00922	45
46	346	347	506	509	697	701	917	926	46
47	348	349	509	512	700	705	921	930	47
48	351	352	512	515	703	708	925	934	48
49	353	354	515	518	707	712	929	938	49
50	.00356	.00357	.00518	.00521	.00710	.00715	.00933	.00942	50
51	358	359	521	524	714	719	937	946	51
52	361	362	524	527	717	722	941	950	52
53	363	364	527	530	721	726	945	954	53
54	365	367	530	533	724	730	949	958	54
55	.00368	.00369	.00533	.00536	.00728	.00733	.00953	.00962	55
56	370	372	536	539	731	737	957	966	56
57	373	374	539	542	735	740	961	970	57
58	375	377	542	545	738	744	965	975	58
59	378	379	545	548	742	747	969	979	59
60	.00381	.00382	.00548	.00551	.00745	.00751	.00973	.00983	60

M.	8°		9°		10°		11°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	E
0	.00973	.00983	.01231	.01247	.01519	.01543	.01837	
1	977	987	236	251	524	548	843	
2	981	991	240	256	529	553	848	
3	985	995	245	261	534	558	854	
4	989	999	249	265	539	564	860	
5	.00994	.01004	.01254	.01270	.01545	.01569	.01865	
6	998	008	259	275	550	574	871	
7	.01002	012	263	279	555	579	876	
8	006	016	268	284	560	585	882	
9	010	020	272	289	565	590	888	
10	.01014	.01024	.01277	.01294	.01570	.01595	.01893	
11	018	029	282	298	575	601	899	
12	022	033	286	303	580	606	904	
13	027	037	291	308	586	611	910	
14	031	041	296	313	591	616	916	
15	.01035	.01046	.01300	.01317	.01596	.01622	.01921	
16	039	050	305	322	601	627	927	
17	043	054	310	327	606	633	933	
18	047	059	314	332	611	638	939	
19	052	063	319	337	617	643	944	
20	.01056	.01067	.01324	.01342	.01622	.01649	.01950	
21	060	071	329	346	627	654	956	
22	064	076	333	351	632	659	961	
23	069	080	338	356	638	665	967	
24	073	084	343	361	643	670	973	
25	.01077	.01089	.01348	.01366	.01648	.01676	.01979	
26	081	093	352	371	653	681	984	
27	086	097	357	376	659	687	990	
28	090	102	362	381	664	692	996	
29	094	106	367	386	669	698	.02002	
30	.01098	.01111	.01371	.01391	.01675	.01703	.02008	
31	103	115	376	395	680	709	013	
32	107	119	381	400	685	714	019	
33	111	124	386	405	690	720	025	
34	116	128	391	410	696	725	031	
35	.01120	.01133	.01396	.01415	.01701	.01731	.02037	
36	124	137	400	420	706	736	042	
37	129	142	405	425	712	742	048	
38	133	146	410	430	717	747	054	
39	137	151	415	435	723	753	060	
40	.01142	.01155	.01420	.01440	.01728	.01758	.02066	
41	146	160	425	445	733	764	072	
42	151	164	430	450	739	769	078	
43	155	169	435	455	744	775	084	
44	159	173	439	460	750	781	090	
45	.01164	.01178	.01444	.01466	.01755	.01786	.02095	
46	168	182	449	471	760	792	101	
47	173	187	454	476	766	798	107	
48	177	191	459	481	771	803	113	
49	182	196	464	486	777	809	119	
50	.01186	.01200	.01469	.01491	.01782	.01815	.02125	
51	191	205	474	496	788	820	131	
52	195	209	479	501	793	826	137	
53	200	214	484	506	799	832	143	
54	204	219	489	512	804	837	149	
55	.01209	.01223	.01494	.01517	.01810	.01843	.02155	
56	213	228	499	522	815	849	161	
57	218	233	504	527	821	854	167	
58	222	237	509	532	826	860	173	
59	227	242	514	537	832	866	179	
60	.01231	.01247	.01519	.01543	.01837	.01872	.02185	

12°		13°		14°		15°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.02185	.02234	.02563	.02630	.02970	.03061	.03407	.03528	0
191	240	570	637	977	069	415	536	1
197	247	576	644	985	076	422	544	2
203	253	583	651	992	084	430	552	3
209	259	589	658	999	091	438	560	4
.02216	.02266	.02596	.02665	.03006	.03099	.03445	.03568	5
222	272	602	672	013	106	453	576	6
228	279	609	679	020	114	460	584	7
234	285	616	686	027	121	468	592	8
240	291	622	693	034	129	476	601	9
.02246	.02298	.02629	.02700	.03041	.03137	.03483	.03609	10
252	304	635	707	048	144	491	617	11
258	311	642	714	055	152	498	625	12
265	317	649	721	063	159	506	633	13
271	323	655	728	070	167	514	642	14
.02277	.02330	.02662	.02735	.03077	.03175	.03521	.03650	15
283	336	669	742	084	182	529	658	16
289	343	675	749	091	190	537	666	17
295	349	682	756	098	197	544	674	18
302	356	689	763	106	205	552	683	19
.02308	.02362	.02696	.02770	.03113	.03213	.03560	.03691	20
314	369	702	777	120	220	567	699	21
320	375	709	784	127	228	575	708	22
327	382	716	791	134	236	583	716	23
333	388	722	799	142	244	590	724	24
.02339	.02395	.02729	.02806	.03149	.03251	.03598	.03732	25
345	402	736	813	156	259	606	741	26
352	408	743	820	163	267	614	749	27
358	415	749	827	171	275	621	758	28
364	421	756	834	178	282	629	766	29
.02370	.02428	.02763	.02842	.03185	.03290	.03637	.03774	30
377	435	770	849	193	298	645	783	31
383	441	777	856	200	306	653	791	32
389	448	783	863	207	313	660	799	33
396	454	790	870	214	321	668	808	34
.02402	.02461	.02797	.02878	.03222	.03329	.03676	.03816	35
408	468	804	885	229	337	684	825	36
415	474	811	892	236	345	692	833	37
421	481	818	899	244	353	699	842	38
427	488	824	907	251	360	707	850	39
.02434	.02494	.02831	.02914	.03258	.03368	.03715	.03858	40
440	501	838	921	266	376	723	867	41
447	508	845	928	273	384	731	875	42
453	515	852	936	281	392	739	884	43
459	521	859	943	288	400	747	892	44
.02466	.02528	.02866	.02950	.03295	.03408	.03754	.03901	45
472	535	873	958	303	416	762	909	46
479	542	880	965	310	424	770	918	47
485	548	887	972	318	432	778	927	48
492	555	894	980	325	439	786	935	49
.02498	.02562	.02900	.02987	.03333	.03447	.03794	.03944	50
504	569	907	994	340	455	802	952	51
511	576	914	.03002	347	463	810	961	52
517	582	921	009	355	471	818	969	53
524	589	928	017	362	479	826	978	54
.02530	.02596	.02935	.03024	.03370	.03487	.03834	.03987	55
537	603	942	032	377	495	842	995	56
543	610	949	039	385	503	850	.04004	57
550	617	956	046	392	511	858	013	58
556	624	963	054	400	520	866	021	59
.02563	.02630	.02970	.03061	.03407	.03528	.03874	.04030	60

M.	16°		17°		18°		19°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exse
0	.03874	.04030	.04370	.04569	.04894	.05146	.05448	.057
1	882	039	378	578	903	156	458	7
2	890	047	387	588	912	166	467	7
3	898	056	395	597	921	176	477	7
4	906	065	404	606	930	186	486	8
5	.03914	.04073	.04412	.04616	.04939	.05196	.05496	.058
6	922	082	421	625	948	206	505	8
7	930	091	429	635	957	216	515	8
8	938	100	438	644	967	226	524	8
9	946	108	446	653	976	236	534	8
10	.03954	.04117	.04455	.04663	.04985	.05246	.05543	.058
11	963	126	464	672	994	256	553	8
12	971	135	472	682	.05003	266	562	8
13	979	144	481	691	012	276	572	9
14	987	152	489	700	021	286	582	9
15	.03995	.04161	.04498	.04710	.05030	.05297	.05591	.059
16	.04003	170	507	719	039	307	601	9
17	011	179	515	729	048	317	610	9
18	019	188	524	738	057	327	620	9
19	028	197	533	748	067	337	630	9
20	.04036	.04206	.04541	.04757	.05076	.05347	.05639	.059
21	044	214	550	767	085	357	649	9
22	052	223	559	776	094	367	658	9
23	060	232	567	786	103	378	668	.060
24	069	241	576	795	112	388	678	0
25	.04077	.04250	.04585	.04805	.05122	.05398	.05687	.060
26	085	259	593	815	131	408	697	0
27	093	268	602	824	140	418	707	0
28	102	277	611	834	149	429	716	0
29	110	286	620	843	158	439	726	0
30	.04118	.04295	.04628	.04853	.05168	.05449	.05736	.060
31	126	304	637	863	177	460	746	0
32	135	313	646	872	186	470	755	1
33	143	322	655	882	195	480	765	1
34	151	331	663	891	205	490	775	1
35	.04159	.04340	.04672	.04901	.05214	.05501	.05785	.061
36	168	349	681	911	223	511	794	1
37	176	358	690	920	232	521	804	1
38	184	367	699	930	242	532	814	1
39	193	376	707	940	251	542	824	1
40	.04201	.04385	.04716	.04950	.05260	.05552	.05833	.061
41	209	394	725	959	270	563	843	2
42	218	403	734	969	279	573	853	2
43	226	413	743	979	288	584	863	2
44	234	422	752	989	298	594	873	2
45	.04243	.04431	.04760	.04998	.05307	.05604	.05882	.062
46	251	440	769	.05008	316	615	892	2
47	260	449	778	018	326	625	902	2
48	268	458	787	028	335	636	912	2
49	276	468	796	038	344	646	922	2
50	.04285	.04477	.04805	.05047	.05354	.05657	.05932	.063
51	293	486	814	057	363	667	942	3
52	302	495	823	067	373	678	951	3
53	310	504	832	077	382	688	961	3
54	319	514	841	087	391	699	971	3
55	.04327	.04523	.04850	.05097	.05401	.05709	.05981	.063
56	336	532	858	107	410	720	991	3
57	344	541	867	116	420	730	.06001	3
58	353	551	876	126	429	741	011	3
59	361	560	885	136	439	751	021	4
60	.04370	.04569	.04894	.05146	.05448	.05762	.06031	.064

20°		21°		22°		23°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.06031	.06418	.06642	.07114	.07282	.07853	.07950	.08636	0
041	429	652	126	293	866	961	649	1
051	440	663	138	303	879	972	663	2
061	452	673	150	314	892	984	676	3
071	463	684	162	325	904	995	690	4
.06081	.06474	.06694	.07174	.07336	.07917	.08006	.08703	5
091	486	705	186	347	930	018	717	6
101	497	715	199	358	943	029	730	7
111	508	726	211	369	955	041	744	8
121	520	736	223	380	968	052	757	9
.06131	.06531	.06747	.07235	.07391	.07981	.08064	.08771	10
141	542	757	247	402	994	075	784	11
151	554	768	259	413	.08006	086	798	12
161	565	778	271	424	019	098	811	13
171	577	789	283	435	032	109	825	14
.06181	.06588	.06799	.07295	.07446	.08045	.08121	.08839	15
191	600	810	307	457	058	132	852	16
201	611	820	320	468	071	144	866	17
211	622	831	332	479	084	155	880	18
221	634	841	344	490	097	167	893	19
.06231	.06645	.06852	.07356	.07501	.08109	.08178	.08907	20
241	657	863	368	512	122	190	920	21
252	668	873	380	523	135	201	934	22
262	680	884	393	534	148	213	948	23
272	691	894	405	545	161	225	962	24
.06282	.06703	.06905	.07417	.07556	.08174	.08236	.08975	25
292	715	916	429	568	187	248	989	26
302	726	926	442	579	200	259	.09003	27
312	738	937	454	590	213	271	017	28
323	749	948	466	601	226	282	030	29
.06333	.06761	.06958	.07479	.07612	.08239	.08294	.09044	30
343	773	969	491	623	252	306	058	31
353	784	980	503	634	265	317	072	32
363	796	990	516	645	278	329	086	33
374	807	.07001	528	657	291	340	099	34
.06384	.06819	.07012	.07540	.07668	.08305	.08352	.09113	35
394	831	022	553	679	318	364	127	36
404	842	033	565	690	331	375	141	37
415	854	044	578	701	344	387	155	38
425	866	055	590	713	357	399	169	39
.06435	.06878	.07065	.07602	.07724	.08370	.08410	.09183	40
445	889	076	615	735	383	422	197	41
456	901	087	627	746	397	434	211	42
466	913	098	640	757	410	445	224	43
476	925	108	652	769	423	457	238	44
.06486	.06936	.07119	.07665	.07780	.08436	.08469	.09252	45
497	948	130	677	791	449	481	266	46
507	960	141	690	802	463	492	280	47
517	972	151	702	814	476	504	294	48
528	984	162	715	825	489	516	308	49
.06538	.06995	.07173	.07727	.07836	.08503	.08528	.09323	50
548	.07007	184	740	848	516	539	337	51
559	019	195	752	859	529	551	351	52
569	031	206	765	870	542	563	365	53
580	043	216	778	881	556	575	379	54
.06590	.07055	.07227	.07790	.07893	.08569	.08586	.09393	55
600	067	238	803	904	582	598	407	56
611	079	249	816	915	596	610	421	57
621	091	260	828	927	609	622	435	58
632	103	271	841	938	623	634	449	59
.06642	.07114	.07282	.07853	.07950	.08636	.08645	.09464	60

M.	24°		25°		26°		27°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Ex
0	.08645	.09464	.09369	.10338	.10121	.11260	.10899	.1
1	657	478	382	353	133	276	913	
2	669	492	394	368	146	292	926	
3	681	506	406	383	159	308	939	
4	693	520	418	398	172	323	952	
5	.08705	.09535	.09431	.10413	.10184	.11339	.10965	.1
6	717	549	443	428	197	355	979	
7	728	563	455	443	210	371	992	
8	740	577	468	458	223	387	.11005	
9	752	592	480	473	236	403	019	
10	.08764	.09606	.09493	.10488	.10248	.11419	.11032	.1
11	776	620	505	503	261	435	045	
12	788	635	517	518	274	451	058	
13	800	649	530	533	287	467	072	
14	812	663	542	549	300	483	085	
15	.08824	.09678	.09554	.10564	.10313	.11499	.11098	.1
16	836	692	567	579	326	515	112	
17	848	707	579	594	338	531	125	
18	860	721	592	609	351	547	138	
19	872	735	604	625	364	563	152	
20	.08884	.09750	.09617	.10640	.10377	.11579	.11165	.1
21	896	764	629	655	390	595	178	
22	908	779	642	670	403	611	192	
23	920	793	654	686	416	627	205	
24	932	808	666	701	429	643	218	
25	.08944	.09822	.09679	.10716	.10442	.11659	.11232	.1
26	956	837	691	731	455	675	245	
27	968	851	704	747	468	691	259	
28	980	866	716	762	481	708	272	
29	992	880	729	777	494	724	285	
30	.09004	.09895	.09741	.10793	.10507	.11740	.11299	.1
31	016	909	754	808	520	756	312	
32	028	924	767	824	533	772	326	
33	040	939	779	839	546	789	339	
34	052	953	792	854	559	805	353	
35	.09064	.09968	.09804	.10870	.10572	.11821	.11366	.1
36	076	982	817	885	585	838	380	
37	089	997	829	901	598	854	393	
38	101	.10012	842	916	611	870	407	
39	113	026	854	932	624	886	420	
40	.09125	.10041	.09867	.10947	.10637	.11903	.11434	.1
41	137	056	880	963	650	919	447	
42	149	071	892	978	663	936	461	
43	161	085	905	994	676	952	474	
44	174	100	918	.11009	689	968	488	
45	.09186	.10115	.09930	.11025	.10702	.11985	.11501	.1
46	198	130	943	041	715	.12001	515	.1
47	210	144	955	056	728	018	528	
48	222	159	968	072	741	034	542	
49	234	174	981	087	755	051	555	
50	.09247	.10189	.09993	.11103	.10768	.12067	.11569	.1
51	259	204	.10006	119	781	083	583	
52	271	218	019	134	794	100	596	
53	283	233	032	150	807	117	610	
54	296	248	044	166	820	133	623	
55	.09308	.10263	.10057	.11181	.10833	.12150	.11637	.1
56	320	278	070	197	847	166	651	
57	332	293	082	213	860	183	664	
58	345	308	095	229	873	199	678	
59	357	323	108	244	886	216	692	
60	.09369	.10338	.10121	.11260	.10899	.12233	.11705	.1

28°		29°		30°		31°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.11705	.13257	.12538	.14335	.13397	.15470	.14283	.16663	0
719	275	552	354	412	489	298	684	1
733	292	566	372	427	509	313	704	2
746	310	580	391	441	528	328	725	3
760	327	594	409	456	548	343	745	4
.11774	.13345	.12609	.14428	.13470	.15567	.14358	.16766	5
787	362	623	446	485	587	373	786	6
801	380	637	465	499	606	388	806	7
815	398	651	483	514	626	403	827	8
828	415	665	502	529	645	418	848	9
.11842	.13433	.12679	.14521	.13543	.15665	.14433	.16868	10
856	451	694	539	558	684	449	889	11
870	468	708	558	573	704	464	909	12
883	486	722	576	587	724	479	930	13
897	504	736	595	602	743	494	950	14
.11911	.13521	.12750	.14614	.13616	.15763	.14509	.16971	15
925	539	765	632	631	782	524	992	16
938	557	779	651	646	802	539	.17012	17
952	575	793	670	660	822	554	033	18
966	593	807	689	675	841	569	054	19
.11980	.13610	.12822	.14707	.13690	.15861	.14584	.17075	20
994	628	836	726	705	881	599	095	21
.12007	646	850	745	719	901	615	116	22
021	664	864	764	734	920	630	137	23
035	682	879	782	749	940	645	158	24
.12049	.13700	.12893	.14801	.13763	.15960	.14660	.17178	25
063	718	907	820	778	980	675	199	26
077	735	921	839	793	.16000	690	220	27
091	753	936	858	808	019	706	241	28
104	771	950	877	822	039	721	262	29
.12118	.13789	.12964	.14896	.13837	.16059	.14736	.17283	30
132	807	979	914	852	079	751	304	31
146	825	993	933	867	099	766	325	32
160	843	.13007	952	881	119	782	346	33
174	861	022	971	896	139	797	367	34
.12188	.13879	.13036	.14990	.13911	.16159	.14812	.17388	35
202	897	051	.15009	926	179	827	409	36
216	915	065	028	941	199	843	430	37
230	934	079	047	955	219	858	451	38
244	952	094	066	970	239	873	472	39
.12257	.13970	.13108	.15085	.13985	.16259	.14888	.17493	40
271	988	122	105	.14000	279	904	514	41
285	.14006	137	124	015	299	919	535	42
299	024	151	143	030	319	934	556	43
313	042	166	162	044	339	949	577	44
.12327	.14061	.13180	.15181	.14059	.16359	.14965	.17598	45
341	079	195	200	074	380	980	620	46
355	097	209	219	089	400	995	641	47
369	115	223	239	104	420	.15011	662	48
383	134	238	258	119	440	026	683	49
.12397	.14152	.13252	.15277	.14134	.16460	.15041	.17704	50
411	170	267	296	149	481	057	726	51
425	188	281	315	164	501	072	747	52
439	207	296	335	179	521	087	768	53
454	225	310	354	194	541	103	790	54
.12468	.14243	.13325	.15373	.14208	.16562	.15118	.17811	55
482	262	339	393	223	582	134	832	56
496	280	354	412	238	602	149	854	57
510	299	368	431	253	623	164	875	58
524	317	383	451	268	643	180	896	59
.12538	.14335	.13397	.15470	.14283	.16663	.15195	.17918	60

M.	32°		33°		34°		35	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	E
0	.15195	.17918	.16133	.19236	.17096	.20622	.18085	
1	211	939	149	259	113	645	101	
2	226	961	165	281	129	669	118	
3	241	982	181	304	145	693	135	
4	257	.18004	196	327	161	717	152	
5	.15272	.18025	.16212	.19349	.17178	.20740	.18168	
6	288	047	228	372	194	764	185	
7	303	068	244	394	210	788	202	
8	319	090	260	417	227	812	218	
9	334	111	276	440	243	836	235	
10	.15350	.18133	.16292	.19463	.17259	.20859	.18252	
11	365	155	308	485	276	883	269	
12	381	176	324	508	292	907	286	
13	396	198	340	531	308	931	302	
14	412	220	355	553	325	955	319	
15	.15427	.18241	.16371	.19576	.17341	.20979	.18336	
16	443	263	387	599	357	.21003	353	
17	458	285	403	622	374	027	369	
18	474	307	419	645	390	051	386	
19	489	328	435	668	407	075	403	
20	.15505	.18350	.16451	.19691	.17423	.21099	.18420	
21	520	372	467	713	439	123	437	
22	536	394	483	736	456	147	454	
23	552	416	499	759	472	171	470	
24	567	437	515	782	489	195	487	
25	.15583	.18459	.16531	.19805	.17505	.21220	.18504	
26	598	481	547	828	522	244	521	
27	614	503	563	851	538	268	538	
28	630	525	579	874	554	292	555	
29	645	547	595	897	571	316	572	
30	.15661	.18569	.16611	.19920	.17587	.21341	.18588	
31	676	591	627	944	604	365	605	
32	692	613	644	967	620	389	622	
33	708	635	660	990	637	414	639	
34	723	657	676	.20013	653	438	656	
35	.15739	.18679	.16692	.20036	.17670	.21462	.18673	
36	755	701	708	059	686	487	690	
37	770	723	724	083	703	511	707	
38	786	745	740	106	719	535	724	
39	802	767	756	129	736	560	741	
40	.15818	.18790	.16772	.20152	.17752	.21584	.18758	
41	833	812	788	176	769	609	775	
42	849	834	805	199	786	633	792	
43	865	856	821	222	802	658	809	
44	880	878	837	246	819	682	826	
45	.15896	.18901	.16853	.20269	.17835	.21707	.18843	
46	912	923	869	292	852	731	860	
47	928	945	885	316	868	756	877	
48	943	967	902	339	885	781	894	
49	959	990	918	363	902	805	911	
50	.15975	.19012	.16934	.20386	.17918	.21830	.18928	
51	991	034	950	410	935	855	945	
52	.16006	057	966	433	952	879	962	
53	022	079	983	457	968	904	979	
54	038	102	999	480	985	929	996	
55	.16054	.19124	.17015	.20504	.18001	.21953	.19013	
56	070	146	031	527	018	978	030	
57	085	169	047	551	035	.22003	047	
58	101	191	064	575	051	028	064	
59	117	214	080	598	068	053	081	
60	.16133	.19236	.17096	.20622	.18085	.22077	.19098	

36°		37°		38°		39°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.19098	.23607	.20136	.25214	.21199	.26902	.22285	.28676	0
115	633	154	241	217	931	304	706	1
133	659	171	269	235	960	322	737	2
150	685	189	296	253	988	340	767	3
167	711	207	324	271	.27017	359	797	4
.19184	.23738	.20224	.25351	.21289	.27046	.22377	.28828	5
201	764	242	379	306	075	395	858	6
218	790	259	406	324	104	414	889	7
235	816	277	434	342	133	432	919	8
252	843	294	462	360	162	450	950	9
.19270	.23869	.20312	.25489	.21378	.27191	.22469	.28980	10
287	895	329	517	396	221	487	.29011	11
304	922	347	545	414	250	506	042	12
321	948	365	572	432	279	524	072	13
338	975	382	600	450	308	542	103	14
.19356	.24001	.20400	.25628	.21468	.27337	.22561	.29133	15
373	028	417	656	486	366	579	164	16
390	054	435	683	504	396	598	195	17
407	081	453	711	522	425	616	226	18
424	107	470	739	540	454	634	256	19
.19442	.24134	.20488	.25767	.21558	.27483	.22653	.29287	20
459	160	506	795	576	513	671	318	21
476	187	523	823	595	542	690	349	22
493	213	541	851	613	572	708	380	23
511	240	559	879	631	601	727	411	24
.19528	.24267	.20576	.25907	.21649	.27630	.22745	.29442	25
545	293	594	935	667	660	764	473	26
562	320	612	963	685	689	782	504	27
580	347	629	991	703	719	801	535	28
597	373	647	.26019	721	748	819	566	29
.19614	.24400	.20665	.26047	.21739	.27778	.22838	.29597	30
632	427	682	075	757	807	856	628	31
649	454	700	104	775	837	875	659	32
666	481	718	132	794	867	893	690	33
684	508	736	160	812	896	912	721	34
.19701	.24534	.20753	.26188	.21830	.27926	.22930	.29752	35
718	561	771	216	848	956	949	784	36
736	588	789	245	866	985	967	815	37
753	615	807	273	884	.28015	986	846	38
770	642	824	301	902	045	.23004	877	39
.19788	.24669	.20842	.26330	.21921	.28075	.23023	.29909	40
805	696	860	358	939	105	041	940	41
822	723	878	387	957	134	060	971	42
840	750	895	415	975	164	079	.30003	43
857	777	913	443	993	194	097	034	44
.19875	.24804	.20931	.26472	.22012	.28224	.23116	.30066	45
892	832	949	500	030	254	134	097	46
909	859	967	529	048	284	153	129	47
927	886	984	557	066	314	172	160	48
944	913	.21002	586	084	344	190	192	49
.19962	.24940	.21020	.26615	.22103	.28374	.23209	.30223	50
979	967	038	643	121	404	228	255	51
997	995	056	672	139	434	246	287	52
.20014	.25022	074	701	157	464	265	318	53
032	049	092	729	176	495	283	350	54
.20049	.25077	.21109	.26758	.22194	.28525	.23302	.30382	55
066	104	127	787	212	555	321	413	56
084	131	145	815	231	585	339	445	57
101	159	163	844	249	615	358	477	58
119	186	181	873	267	646	377	509	59
.20136	.25214	.21199	.26902	.22285	.28676	.23396	.30541	60

M.	40°		41°		42°		43°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	E
0	.23396	.30541	.24529	.32501	.25686	.34563	.26865	.
1	414	573	548	535	705	599	884	
2	433	605	567	568	724	634	904	
3	452	636	586	602	744	669	924	
4	470	668	605	636	763	704	944	
5	.23489	.30700	.24625	.32669	.25783	.34740	.26964	.
6	508	732	644	703	802	775	984	
7	527	764	663	737	822	811	.27004	
8	545	796	682	770	841	846	024	.
9	564	829	701	804	861	882	043	
10	.23583	.30861	.24720	.32838	.25880	.34917	.27063	.
11	602	893	739	872	900	953	083	
12	620	925	759	905	920	988	103	
13	639	957	778	939	939	.35024	123	
14	658	989	797	973	959	060	143	
15	.23677	.31022	.24816	.33007	.25978	.35095	.27163	.
16	696	054	835	041	998	131	183	
17	714	086	854	075	.26017	167	203	
18	733	119	874	109	037	203	223	
19	752	151	893	143	056	238	243	
20	.23771	.31183	.24912	.33177	.26076	.35274	.27263	.
21	790	216	931	211	096	310	283	
22	808	248	950	245	115	346	303	
23	827	281	970	279	135	382	323	
24	846	313	989	314	154	418	343	
25	.23865	.31346	.25008	.33348	.26174	.35454	.27363	.
26	884	378	027	382	194	490	383	
27	903	411	047	416	213	526	403	
28	922	443	066	451	233	562	423	
29	941	476	085	485	253	598	443	
30	.23959	.31509	.25104	.33519	.26272	.35634	.27463	.
31	978	541	124	554	292	670	483	
32	997	574	143	588	312	707	503	
33	.24016	607	162	622	331	743	523	
34	035	640	182	657	351	779	543	.
35	.24054	.31672	.25201	.33691	.26371	.35815	.27563	.
36	073	705	220	726	390	852	583	
37	092	738	240	760	410	888	603	
38	111	771	259	795	430	924	623	
39	130	804	278	830	449	961	643	
40	.24149	.31837	.25297	.33864	.26469	.35997	.27663	.
41	168	870	317	899	489	.36034	683	
42	187	903	336	934	509	070	703	
43	206	936	356	968	528	107	723	
44	225	969	375	.34003	548	143	743	
45	.24244	.32002	.25394	.34038	.26568	.36180	.27764	.
46	262	035	414	073	587	217	784	
47	281	068	433	108	607	253	804	
48	300	101	452	142	627	290	824	
49	320	134	472	177	647	327	844	
50	.24339	.32168	.25491	.34212	.26667	.36363	.27864	.
51	358	201	511	247	686	400	884	
52	377	234	530	282	706	437	905	
53	396	267	549	317	726	474	925	
54	415	301	569	352	746	511	945	
55	.24434	.32334	.25588	.34387	.26766	.36548	.27965	.
56	453	368	608	423	785	585	985	
57	472	401	627	458	805	622	.28005	
58	491	434	647	493	825	659	026	
59	510	468	666	528	845	696	046	
60	.24529	.32501	.25686	.34563	.26865	.36733	.28086	.

44°		45°		46°		47°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.28066	.39016	.29289	.41421	.30534	.43956	.31800	.46628	0
086	055	310	463	555	999	821	674	1
106	095	330	504	576	.44042	843	719	2
127	134	351	545	597	086	864	765	3
147	173	372	586	618	129	885	811	4
.28167	.39212	.29392	.41627	.30639	.44173	.31907	.46857	5
187	251	413	669	660	217	928	903	6
208	291	433	710	681	260	949	949	7
228	330	454	752	702	304	971	995	8
248	369	475	793	723	347	992	.47041	9
.28268	.39409	.29495	.41835	.30744	.44391	.32013	.47087	10
289	448	516	876	765	435	035	134	11
309	487	537	918	786	479	056	180	12
329	527	557	959	807	523	077	226	13
350	566	578	.42001	828	567	099	272	14
.28370	.39606	.29599	.42042	.30849	.44610	.32120	.47319	15
390	646	619	084	870	654	141	365	16
410	685	640	126	891	698	163	411	17
431	725	661	168	912	742	184	458	18
451	764	681	209	933	787	205	504	19
.28471	.39804	.29702	.42251	.30954	.44831	.32227	.47551	20
492	844	723	293	975	875	248	598	21
512	884	743	335	996	919	270	644	22
532	924	764	377	.31017	963	291	691	23
553	963	785	419	038	.45007	312	738	24
.28573	.40003	.29805	.42461	.31059	.45052	.32334	.47784	25
593	043	826	503	080	096	355	831	26
614	083	847	545	101	141	377	878	27
634	123	868	587	122	185	398	925	28
655	163	888	630	143	229	420	972	29
.28675	.40203	.29909	.42672	.31165	.45274	.32441	.48019	30
695	243	930	714	186	319	462	066	31
716	283	951	756	207	363	484	113	32
736	324	971	799	228	408	505	160	33
757	364	992	841	249	452	527	207	34
.28777	.40404	.30013	.42883	.31270	.45497	.32548	.48254	35
797	444	034	926	291	542	570	301	36
818	485	054	968	312	587	591	349	37
838	525	075	.43011	334	631	613	396	38
859	565	096	053	355	676	634	443	39
.28879	.40606	.30117	.43096	.31376	.45721	.32656	.48491	40
900	646	138	139	397	766	677	538	41
920	687	158	181	418	811	699	586	42
941	727	179	224	439	856	720	633	43
961	768	200	267	461	901	742	681	44
.28981	.40808	.30221	.43309	.31482	.45946	.32763	.48728	45
.29002	849	242	352	503	992	785	776	46
022	890	263	395	524	.46037	806	824	47
043	930	283	438	545	082	828	871	48
063	971	304	481	566	127	849	919	49
.29084	.41012	.30325	.43524	.31588	.46173	.32871	.48967	50
104	053	346	567	609	218	893	.49015	51
125	093	367	610	630	263	914	063	52
145	134	388	653	651	309	936	111	53
166	175	409	696	673	354	957	159	54
.29187	.41216	.30430	.43739	.31694	.46400	.32979	.49207	55
207	257	451	783	715	445	.33001	255	56
228	298	471	826	736	491	022	303	57
248	339	492	869	758	537	044	351	58
269	380	513	912	779	582	065	399	59
.29289	.41421	.30534	.43956	.31800	.46628	.33087	.49448	60

M.	48°		49°		50°		51°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	E
0	.33087	.49448	.34394	.52425	.35721	.55572	.37068	.
1	109	496	416	476	744	626	091	.
2	130	544	438	527	766	680	113	.
3	152	593	460	579	788	734	136	
4	173	641	482	630	810	789	158	
5	.33195	.49690	.34504	.52681	.35833	.55843	.37181	.
6	217	738	526	732	855	897	204	
7	238	787	548	784	877	951	226	
8	260	835	570	835	900	.56005	249	
9	282	884	592	886	922	060	272	
10	.33303	.49933	.34614	.52938	.35944	.56114	.37294	.
11	325	981	636	989	967	169	317	
12	347	.50030	658	.53041	989	223	340	
13	368	079	680	092	.36011	278	362	
14	390	128	702	144	034	332	385	
15	.33412	.50177	.34724	.53196	.36056	.56387	.37408	.
16	434	226	746	247	078	442	430	
17	455	275	768	299	101	497	453	
18	477	324	790	351	123	551	476	
19	499	373	812	403	146	606	498	
20	.33520	.50422	.34834	.53455	.36168	.56661	.37521	.
21	542	471	856	507	190	716	544	
22	564	521	878	559	213	771	567	
23	586	570	900	611	235	826	589	
24	607	619	923	663	258	881	612	
25	.33629	.50669	.34945	.53715	.36280	.56937	.37635	.
26	651	718	967	768	302	992	658	
27	673	767	989	820	325	.57047	680	
28	694	817	.35011	872	347	103	703	
29	716	866	033	924	370	158	726	
30	.33738	.50916	.35055	.53977	.36392	.57213	.37749	.
31	760	966	077	.54029	415	269	771	
32	782	.51015	099	082	437	324	794	
33	803	065	122	134	460	380	817	
34	825	115	144	187	482	436	840	
35	.33847	.51165	.35166	.54240	.36504	.57491	.37862	.
36	869	215	188	292	527	547	885	
37	891	265	210	345	549	603	908	.
38	912	314	232	398	572	659	931	
39	934	364	254	451	594	715	954	
40	.33956	.51415	.35277	.54504	.36617	.57771	.37976	.
41	978	465	299	557	639	827	999	
42	.34000	515	321	610	662	883	.38022	
43	022	565	343	663	684	939	045	
44	044	615	365	716	707	995	068	
45	.34065	.51665	.35388	.54769	.36729	.58051	.38091	.
46	087	716	410	822	752	108	113	
47	109	766	432	876	775	164	136	
48	131	817	454	929	797	221	159	
49	153	867	476	982	820	277	182	
50	.34175	.51918	.35499	.55036	.36842	.58333	.38205	.
51	197	968	521	089	865	390	228	
52	219	.52019	543	143	887	447	251	
53	241	069	565	196	910	503	274	.
54	262	120	588	250	932	560	296	
55	.34284	.52171	.35610	.55303	.36955	.58617	.38319	.
56	306	222	632	357	978	674	342	
57	328	273	654	411	.37000	731	365	
58	350	323	677	465	023	788	388	
59	372	374	699	518	045	845	411	
60	.34394	.52425	.35721	.55572	.37068	.58902	.38434	.

52°		53°		54°		55°		M.
.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
4	.62427	.39818	.66164	.41221	.70130	.42642	.74345	0
7	487	842	228	245	198	666	417	1
0	548	865	292	269	267	690	490	2
3	609	888	357	292	335	714	562	3
6	669	911	421	316	403	738	635	4
9	.62730	.39935	.66486	.41339	.70472	.42762	.74708	5
1	791	958	550	363	540	785	781	6
4	852	981	615	386	609	809	854	7
7	913	.40005	679	410	677	833	927	8
0	974	028	744	433	746	857	.75000	9
3	.63035	.40051	.66809	.41457	.70815	.42881	.75073	10
6	096	074	873	481	884	905	146	11
9	157	098	938	504	953	929	219	12
2	218	121	.67003	528	.71022	953	293	13
5	279	144	068	551	091	976	366	14
8	.63341	.40168	.67133	.41575	.71160	.43000	.75440	15
1	402	191	198	599	229	024	513	16
4	464	214	264	622	298	048	587	17
7	525	237	329	646	368	072	661	18
0	587	261	394	670	437	096	734	19
3	.63648	.40284	.67460	.41693	.71506	.43120	.75808	20
6	710	307	525	717	576	144	882	21
9	772	331	591	740	646	168	956	22
2	834	354	656	764	715	192	.76031	23
5	895	378	722	788	785	216	105	24
9	.63957	.40401	.67788	.41811	.71855	.43240	.76179	25
2	.64019	424	853	835	925	264	253	26
5	081	448	919	859	995	287	328	27
8	144	471	985	882	.72065	311	402	28
1	206	494	.68051	906	135	335	477	29
4	.64268	.40518	.68117	.41930	.72205	.43359	.76552	30
7	330	541	183	953	275	383	626	31
0	393	564	250	977	346	407	701	32
3	455	588	316	.42001	416	431	776	33
6	518	611	382	024	487	455	851	34
9	.64580	.40635	.68449	.42048	.72557	.43479	.76926	35
2	643	658	515	072	628	503	.77001	36
6	705	682	582	096	698	527	077	37
9	768	705	648	119	769	551	152	38
2	831	728	715	143	840	575	227	39
5	.64894	.40752	.68782	.42167	.72911	.43599	.77303	40
8	957	775	848	190	982	623	378	41
1	.65020	799	915	214	.73053	647	454	42
4	083	822	982	238	124	671	530	43
7	146	846	.69049	262	195	695	606	44
1	.65209	.40869	.69116	.42285	.73267	.43720	.77681	45
4	272	892	183	309	338	744	757	46
7	335	916	250	333	409	768	833	47
0	399	939	318	357	481	792	910	48
3	462	963	385	381	552	816	986	49
6	.65526	.40986	.69452	.42404	.73624	.43840	.78062	50
9	589	.41010	520	428	696	864	138	51
3	653	033	587	452	768	888	215	52
6	717	057	655	476	840	912	291	53
9	780	080	723	499	911	936	368	54
2	.65844	.41104	.69790	.42523	.73983	.43960	.78445	55
5	908	127	858	547	.74056	984	521	56
9	972	151	926	571	128	.44008	598	57
2	.66036	174	994	595	200	032	675	58
5	100	198	.70062	619	272	057	752	59
8	.66164	.41221	.70130	.42642	.74345	.44081	.78829	60

M.	56°		57°		58°		59°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.
0	.44081	.78829	.45536	.83608	.47008	.88708	.48496	.94160
1	105	906	560	690	033	796	521	254
2	129	984	585	773	057	884	546	349
3	153	.79061	609	855	082	972	571	443
4	177	138	634	938	107	.89060	596	537
5	.44201	.79216	.45658	.84020	.47131	.89148	.48621	.94632
6	225	293	683	103	156	237	646	726
7	250	371	707	186	181	325	671	821
8	274	449	731	269	206	414	696	916
9	298	527	756	352	230	503	721	.95011
10	.44322	.79604	.45780	.84435	.47255	.89591	.48746	.95106
11	346	682	805	518	280	680	771	201
12	370	761	829	601	304	769	796	296
13	395	839	854	685	329	858	821	392
14	419	917	878	768	354	948	846	487
15	44443	.79995	.45903	.84852	.47379	.90037	.48871	.95583
16	467	.80074	927	935	403	126	896	678
17	491	152	951	.85019	428	216	921	774
18	516	231	976	103	453	305	946	870
19	540	309	.46000	187	478	395	971	966
20	.44564	.80388	.46025	.85271	.47502	.90485	.48996	.96062
21	588	467	049	355	527	575	.49021	158
22	612	546	074	439	552	665	046	255
23	637	625	098	523	577	755	071	351
24	661	704	123	608	601	845	096	448
25	.44685	.80783	.46147	.85692	.47626	.90935	.49121	.96544
26	709	862	172	777	651	.91026	146	641
27	734	942	196	861	676	116	171	738
28	758	.81021	221	946	701	207	196	835
29	782	101	246	.86031	725	297	221	932
30	.44806	.81180	.46270	.86116	.47750	.91388	.49246	.97029
31	831	260	295	201	775	479	271	127
32	855	340	319	286	800	570	296	224
33	879	419	344	371	825	661	321	322
34	903	499	368	457	849	752	346	420
35	.44928	.81579	.46393	.86542	.47874	.91844	.49372	.97517
36	952	659	417	627	899	935	397	615
37	976	740	442	713	924	.92027	422	713
38	.45001	820	466	799	949	118	447	811
39	025	900	491	885	974	210	472	910
40	.45049	.81981	.46516	.86970	.47998	.92302	.49497	.98008
41	073	.82061	540	.87056	.48023	394	522	107
42	098	142	565	142	048	486	547	205
43	122	222	589	229	073	578	572	304
44	146	303	614	315	098	670	597	403
45	.45171	.82384	.46639	.87401	.48123	.92762	.49623	.98502
46	195	465	663	488	148	855	648	601
47	219	546	688	574	172	947	673	700
48	244	627	712	661	197	.93040	698	799
49	268	709	737	748	222	133	723	899
50	.45292	.82790	.46762	.87834	.48247	.93226	.49748	.99098
51	317	871	786	921	272	319	773	.99098
52	341	953	811	.88008	297	412	799	198
53	365	.83034	836	095	322	505	824	298
54	390	116	860	183	347	598	849	398
55	.45414	.83198	.46885	.88270	.48372	.93692	.49874	.99498
56	439	280	909	357	396	785	899	598
57	463	362	934	445	421	879	924	698
58	487	444	959	532	446	973	950	798
1	512	526	983	620	471	.94066	975	898
	.45536	.83608	.47008	.88708	.48496	.94160	.50000	1.0000

60°		61°		62°		63°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.50000	1.00000	.51519	1.06267	.53053	1.13005	.54601	1.20269	0
025	.00101	544	.06375	079	.13122	627	.20395	1
050	.00202	570	.06483	104	.13239	653	.20521	2
076	.00303	595	.06592	130	.13356	679	.20647	3
101	.00404	621	.06701	156	.13473	705	.20773	4
.50126	1.00505	.51646	1.06809	.53181	1.13590	.54731	1.20900	5
151	.00607	672	.06918	207	.13707	757	.21026	6
176	.00708	697	.07027	233	.13825	782	.21153	7
202	.00810	723	.07137	258	.13942	808	.21280	8
227	.00912	748	.07246	284	.14060	834	.21407	9
.50252	1.01014	.51774	1.07356	.53310	1.14178	.54860	1.21535	10
277	.01116	799	.07465	336	.14296	886	.21662	11
303	.01218	825	.07575	361	.14414	912	.21790	12
328	.01320	850	.07685	387	.14533	938	.21918	13
353	.01422	876	.07795	413	.14651	964	.22045	14
.50378	1.01525	.51901	1.07905	.53439	1.14770	.54990	1.22174	15
404	.01628	927	.08015	464	.14889	.55016	.22302	16
429	.01730	952	.08126	490	.15008	042	.22430	17
454	.01833	978	.08236	516	.15127	068	.22559	18
479	.01936	.52003	.08347	542	.15246	094	.22688	19
.50505	1.02039	.52029	1.08458	.53567	1.15366	.55120	1.22817	20
530	.02143	054	.08569	593	.15485	146	.22946	21
555	.02246	080	.08680	619	.15605	172	.23075	22
581	.02349	105	.08791	645	.15725	198	.23205	23
606	.02453	131	.08903	670	.15845	224	.23334	24
.50631	1.02557	.52156	1.09014	.53696	1.15965	.55250	1.23464	25
656	.02661	182	.09126	722	.16085	276	.23594	26
682	.02765	207	.09238	748	.16206	302	.23724	27
707	.02869	233	.09350	774	.16326	328	.23855	28
732	.02973	259	.09462	799	.16447	354	.23985	29
.50758	1.03077	.52284	1.09574	.53825	1.16568	.55380	1.24116	30
783	.03182	310	.09686	851	.16689	406	.24247	31
808	.03286	335	.09799	877	.16810	432	.24378	32
834	.03391	361	.09911	903	.16932	458	.24509	33
859	.03496	386	.10024	928	.17053	484	.24640	34
.50884	1.03601	.52412	1.10137	.53954	1.17175	.55510	1.24772	35
910	.03706	438	.10250	980	.17297	536	.24903	36
935	.03811	463	.10363	.54006	.17419	563	.25035	37
960	.03916	489	.10477	032	.17541	589	.25167	38
986	.04022	514	.10590	058	.17663	615	.25300	39
.51011	1.04128	.52540	1.10704	.54083	1.17786	.55641	1.25432	40
036	.04233	566	.10817	109	.17909	667	.25565	41
062	.04339	591	.10931	135	.18031	693	.25697	42
087	.04445	617	.11045	161	.18154	719	.25830	43
112	.04551	642	.11159	187	.18277	745	.25963	44
.51138	1.04657	.52668	1.11274	.54213	1.18401	.55771	1.26097	45
163	.04764	694	.11388	238	.18524	797	.26230	46
189	.04870	719	.11503	264	.18648	823	.26364	47
214	.04977	745	.11617	290	.18772	849	.26498	48
239	.05084	771	.11732	316	.18895	876	.26632	49
.51265	1.05191	.52796	1.11847	.54342	1.19019	.55902	1.26766	50
290	.05298	822	.11963	368	.19144	928	.26900	51
316	.05405	847	.12078	394	.19268	954	.27035	52
341	.05512	873	.12193	420	.19393	980	.27169	53
366	.05619	899	.12309	446	.19517	.56006	.27304	54
.51392	1.05727	.52924	1.12425	.54471	1.19642	.56032	1.27439	55
417	.05835	950	.12540	497	.19767	058	.27574	56
443	.05942	976	.12657	523	.19892	084	.27710	57
468	.06050	.53001	.12773	549	.20018	111	.27845	58
494	.06158	027	.12889	575	.20143	137	.27981	59
.51519	1.06267	.53053	1.13005	.54601	1.20269	.56163	1.28117	60

M.	64°		65°		66°		67°		M.
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
0	.56163	1.28117	.57738	1.36620	.59326	1.45859	.60927	1.55930	0
1	189	.28253	765	.36768	353	.46020	954	.56106	1
2	215	.28390	791	.36916	379	.46181	980	.56282	2
3	241	.28526	817	.37064	406	.46342	.61007	.56458	3
4	267	.28663	844	.37212	433	.46504	034	.56634	4
5	.56294	1.28800	.57870	1.37361	.59459	1.46665	.61061	1.56811	5
6	320	.28937	896	.37509	486	.46827	088	.56988	6
7	346	.29074	923	.37658	512	.46989	114	.57165	7
8	372	.29211	949	.37808	539	.47152	141	.57342	8
9	398	.29349	976	.37957	566	.47314	168	.57520	9
10	.56425	1.29487	.58002	1.38107	.59592	1.47477	.61195	1.57698	10
11	451	.29625	028	.38256	619	.47640	222	.57876	11
12	477	.29763	055	.38406	645	.47804	248	.58054	12
13	503	.29901	081	.38556	672	.47967	275	.58233	13
14	529	.30040	108	.38707	699	.48131	302	.58412	14
15	.56555	1.30179	.58134	1.38857	.59725	1.48295	.61329	1.58591	15
16	582	.30318	160	.39008	752	.48459	356	.58771	16
17	608	.30457	187	.39159	779	.48624	383	.58950	17
18	634	.30596	213	.39311	805	.48789	409	.59130	18
19	660	.30735	240	.39462	832	.48954	436	.59311	19
20	.56687	1.30875	.58266	1.39614	.59859	1.49119	.61463	1.59491	20
21	713	.31015	293	.39766	885	.49284	490	.59672	21
22	739	.31155	319	.39918	912	.49450	517	.59853	22
23	765	.31295	345	.40070	938	.49616	544	.60035	23
24	791	.31436	372	.40222	965	.49782	570	.60217	24
25	.56818	1.31576	.58398	1.40375	.59992	1.49948	.61597	1.60399	25
26	844	.31717	425	.40528	.60018	.50115	624	.60581	26
27	870	.31858	451	.40681	045	.50282	651	.60763	27
28	896	.31999	478	.40835	072	.50449	678	.60946	28
29	923	.32140	504	.40988	098	.50617	705	.61129	29
30	.56949	1.32282	.58531	1.41142	.60125	1.50784	.61732	1.61313	30
31	975	.32424	557	.41296	152	.50952	759	.61496	31
32	.57001	.32566	584	.41450	178	.51120	785	.61680	32
33	028	.32708	610	.41605	205	.51289	812	.61864	33
34	054	.32850	637	.41760	232	.51457	839	.62049	34
35	.57080	1.32993	.58663	1.41914	.60259	1.51626	.61866	1.62234	35
36	106	.33135	690	.42070	285	.51795	893	.62419	36
37	133	.33278	716	.42225	312	.51965	920	.62604	37
38	159	.33422	743	.42380	339	.52134	947	.62790	38
39	185	.33565	769	.42536	365	.52304	974	.62976	39
40	.57212	1.33708	.58796	1.42692	.60392	1.52474	.62001	1.63162	40
41	238	.33852	822	.42848	419	.52645	027	.63348	41
42	264	.33996	849	.43005	445	.52815	054	.63535	42
43	291	.34140	875	.43162	472	.52986	081	.63722	43
44	317	.34284	902	.43318	499	.53157	108	.63909	44
45	.57343	1.34429	.58928	1.43476	.60526	1.53329	.62135	1.64097	45
46	369	.34573	955	.43633	552	.53500	162	.64285	46
47	396	.34718	981	.43790	579	.53672	189	.64473	47
48	422	.34863	.59008	.43948	606	.53845	216	.64662	48
49	448	.35009	034	.44106	633	.54017	243	.64851	49
50	.57475	1.35154	.59061	1.44264	.60659	1.54190	.62270	1.65040	50
51	501	.35300	087	.44423	686	.54363	297	.65229	51
52	527	.35446	114	.44582	713	.54536	324	.65419	52
53	554	.35592	140	.44741	740	.54709	351	.65609	53
54	580	.35738	167	.44900	766	.54883	378	.65799	54
55	.57606	1.35885	.59194	1.45059	.60793	1.55057	.62405	1.65989	55
56	633	.36031	220	.45219	820	.55231	431	.66180	56
57	659	.36178	247	.45378	847	.55405	458	.66371	57
58	685	.36325	273	.45539	873	.55580	485	.66563	58
59	712	.36473	300	.45699	900	.55755	512	.66755	59
60	.57738	1.36620	.59326	1.45859	.60927	1.55930	.62539	1.66948	60

68°		69°		70°		71°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.62539	1.66947	.64163	1.79043	.65798	1.92380	.67443	2.07155	0
566	.67139	190	.79254	825	.92614	471	.07415	1
593	.67332	218	.79466	853	.92849	498	.07675	2
620	.67525	245	.79679	880	.93083	526	.07936	3
647	.67718	272	.79891	907	.93318	553	.08197	4
.62674	1.67911	.64299	1.80104	.65935	1.93554	.67581	2.08459	5
701	.68105	326	.80318	962	.93790	608	.08721	6
728	.68299	353	.80531	989	.94026	636	.08983	7
755	.68494	381	.80746	.66017	.94263	663	.09246	8
782	.68689	408	.80960	044	.94500	691	.09510	9
.62809	1.68884	.64435	1.81175	.66071	1.94737	.67718	2.09774	10
836	.69079	462	.81390	099	.94975	746	.10038	11
863	.69275	489	.81605	126	.95213	773	.10303	12
890	.69471	516	.81821	154	.95452	801	.10568	13
917	.69667	544	.82037	181	.95691	829	.10834	14
.62944	1.69864	.64571	1.82254	.66208	1.95931	.67856	2.11101	15
971	.70061	598	.82471	236	.96171	884	.11367	16
998	.70258	625	.82688	263	.96411	911	.11635	17
.63025	.70455	653	.82906	290	.96652	939	.11903	18
052	.70653	680	.83124	318	.96893	966	.12171	19
.63079	1.70851	.64707	1.83342	.66345	1.97135	.67994	2.12440	20
106	.71050	734	.83561	373	.97377	.68021	.12709	21
133	.71249	761	.83780	400	.97619	049	.12979	22
161	.71448	789	.83999	427	.97862	077	.13249	23
188	.71647	816	.84219	455	.98106	104	.13520	24
.63215	1.71847	.64843	1.84439	.66482	1.98349	.68132	2.13791	25
242	.72047	870	.84659	510	.98594	159	.14063	26
269	.72247	898	.84880	537	.98838	187	.14335	27
296	.72448	925	.85102	564	.99083	214	.14608	28
323	.72649	952	.85323	592	.99329	242	.14881	29
.63350	1.72850	.64979	1.85545	.66619	1.99574	.68270	2.15155	30
377	.73052	.65007	.85767	647	.99821	297	.15429	31
404	.73254	034	.85990	674	2.00067	325	.15704	32
431	.73456	061	.86213	702	.00315	352	.15979	33
458	.73659	088	.86437	729	.00562	380	.16255	34
.63485	1.73862	.65116	1.86661	.66756	2.00810	.68407	2.16531	35
512	.74065	143	.86885	784	.01059	435	.16808	36
539	.74269	170	.87109	811	.01308	463	.17085	37
566	.74473	197	.87334	839	.01557	490	.17363	38
594	.74677	225	.87560	866	.01807	518	.17641	39
.63621	1.74881	.65252	1.87785	.66894	2.02057	.68546	2.17920	40
648	.75086	279	.88011	921	.02308	573	.18199	41
675	.75292	306	.88238	949	.02559	601	.18479	42
702	.75497	334	.88465	976	.02810	628	.18759	43
729	.75703	361	.88692	.67003	.03062	656	.19040	44
.63756	1.75909	.65388	1.88920	.67031	2.03315	.68684	2.19322	45
783	.76116	416	.89148	058	.03568	711	.19604	46
810	.76323	443	.89376	086	.03821	739	.19886	47
838	.76530	470	.89605	113	.04075	767	.20169	48
865	.76737	497	.89834	141	.04329	794	.20453	49
.63892	1.76945	.65525	1.90063	.67168	2.04584	.68822	2.20737	50
919	.77154	552	.90293	196	.04839	849	.21021	51
946	.77362	579	.90524	223	.05094	877	.21306	52
973	.77571	607	.90754	251	.05350	905	.21592	53
.64000	.77780	634	.90986	278	.05607	932	.21878	54
.64027	1.77990	.65661	1.91217	.67306	2.05864	.68960	2.22165	55
055	.78200	689	.91449	333	.06121	988	.22452	56
082	.78410	716	.91681	361	.06379	.69015	.22740	57
109	.78621	743	.91914	388	.06637	043	.23028	58
136	.78832	771	.92147	416	.06896	071	.23317	59
.64163	1.79043	.65798	1.92380	.67443	2.07155	.69098	2.23607	60

M.	72°		73°		74°		75°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Ex
0	.69098	2.23607	.70763	2.42030	.72436	2.62796	.74118	2.8
1	126	.23897	791	.42356	464	.63164	146	.8
2	154	.24187	818	.42683	492	.63533	174	.8
3	181	.24478	846	.43010	520	.63903	202	.8
4	209	.24770	874	.43337	548	.64274	231	.8
5	.69237	2.25062	.70902	2.43666	.72576	2.64645	.74259	2.8
6	264	.25355	930	.43995	604	.65018	287	.8
7	292	.25648	958	.44324	632	.65391	315	.8
8	320	.25942	985	.44655	660	.65765	343	.8
9	347	.26237	.71013	.44986	688	.66140	371	.9
10	.69375	2.26531	.71041	2.45317	.72716	2.66515	.74399	2.9
11	403	.26827	069	.45650	744	.66892	427	.9
12	430	.27123	097	.45983	772	.67269	455	.9
13	458	.27420	125	.46316	800	.67647	484	.9
14	486	.27717	153	.46651	828	.68025	512	.9
15	.69514	2.28015	.71180	2.46986	.72856	2.68405	.74540	2.9
16	541	.28313	208	.47321	884	.68785	568	.9
17	569	.28612	236	.47658	912	.69167	596	.9
18	597	.28912	264	.47995	940	.69549	624	.9
19	624	.29212	292	.48333	968	.69931	652	.9
20	.69652	2.29512	.71320	2.48671	.72996	2.70315	.74680	2.9
21	680	.29814	348	.49010	.73024	.70700	709	.9
22	708	.30115	375	.49350	052	.71085	737	.9
23	735	.30418	403	.49691	080	.71471	765	.9
24	763	.30721	431	.50032	108	.71858	793	.9
25	.69791	2.31024	.71459	2.50374	.73136	2.72246	.74821	2.9
26	818	.31328	487	.50716	164	.72635	849	.9
27	846	.31633	515	.51060	192	.73024	878	.9
28	874	.31939	543	.51404	220	.73414	906	.9
29	902	.32244	571	.51748	248	.73806	934	.9
30	.69929	2.32551	.71598	2.52094	.73276	2.74198	.74962	2.9
31	957	.32858	626	.52440	304	.74591	990	.9
32	985	.33166	654	.52787	332	.74984	.75018	3.0
33	.70013	.33474	682	.53134	360	.75379	046	.0
34	040	.33783	710	.53482	388	.75775	075	.0
35	.70068	2.34092	.71738	2.53831	.73416	2.76171	.75103	3.0
36	096	.34403	766	.54181	444	.76568	131	.0
37	124	.34713	794	.54531	472	.76966	159	.0
38	151	.35025	822	.54883	500	.77365	187	.0
39	179	.35336	850	.55234	529	.77765	216	.0
40	.70207	2.35649	.71877	2.55587	.73557	2.78166	.75244	3.0
41	235	.35962	905	.55940	585	.78568	272	.0
42	263	.36276	933	.56294	613	.78970	300	.0
43	290	.36590	961	.56649	641	.79374	328	.0
44	318	.36905	989	.57005	669	.79778	356	.0
45	.70346	2.37221	.72017	2.57361	.73697	2.80183	.75385	3.0
46	374	.37537	045	.57718	725	.80589	413	.0
47	401	.37854	073	.58076	753	.80996	441	.0
48	429	.38171	101	.58434	781	.81404	469	.0
49	457	.38489	129	.58794	809	.81813	497	.0
50	.70485	2.38808	.72157	2.59154	.73837	2.82223	.75526	3.0
51	513	.39128	185	.59514	865	.82633	554	.0
52	540	.39448	213	.59876	893	.83045	582	.0
53	568	.39768	241	.60238	921	.83457	610	.1
54	596	.40089	269	.60601	950	.83871	638	.1
55	.70624	2.40411	.72296	2.60965	.73978	2.84285	.75667	3.1
56	652	.40734	324	.61330	.74006	.84700	695	.1
57	679	.41057	352	.61695	034	.85116	723	.1
58	707	.41381	380	.62061	062	.85533	751	.1
59	735	.41705	408	.62428	090	.85951	780	.1
60	.70763	2.42030	.72436	2.62796	.74118	2.86370	.75808	3.1

76°		77°		78°		79°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.75808	3.13357	.77505	3.44541	.79209	3.80973	.80919	4.24084	0
836	.13839	533	.45102	237	.81633	948	.24870	1
864	.14323	562	.45664	266	.82294	976	.25658	2
892	.14809	590	.46228	294	.82956	.81005	.26448	3
921	.15295	618	.46793	323	.83621	033	.27241	4
.75949	3.15782	.77647	3.47360	.79351	3.84288	.81062	4.28036	5
977	.16271	675	.47928	380	.84956	090	.28833	6
.76005	.16761	703	.48498	408	.85627	119	.29634	7
034	.17252	732	.49069	437	.86299	148	.30436	8
062	.17744	760	.49642	465	.86973	176	.31241	9
.76090	3.18238	.77788	3.50216	.79493	3.87649	.81205	4.32049	10
118	.18733	817	.50791	522	.88327	233	.32859	11
147	.19228	845	.51368	550	.89007	262	.33671	12
175	.19725	874	.51947	579	.89689	290	.34486	13
203	.20224	902	.52527	607	.90373	319	.35304	14
.76231	3.20723	.77930	3.53109	.79636	3.91058	.81348	4.36124	15
260	.21224	959	.53692	664	.91746	376	.36947	16
288	.21726	987	.54277	693	.92436	405	.37772	17
316	.22229	.78015	.54863	721	.93128	433	.38600	18
344	.22734	044	.55451	750	.93821	462	.39430	19
.76373	3.23239	.78072	3.56041	.79778	3.94517	.81491	4.40263	20
401	.23746	101	.56632	807	.95215	519	.41099	21
429	.24255	129	.57224	835	.95914	548	.41937	22
458	.24764	157	.57819	864	.96616	576	.42778	23
486	.25275	186	.58414	892	.97320	605	.43622	24
.76514	3.25787	.78214	3.59012	.79921	3.98025	.81633	4.44468	25
542	.26300	242	.59611	949	.98733	662	.45317	26
571	.26814	271	.60211	978	.99443	691	.46169	27
599	.27330	299	.60813	.80006	4.00155	719	.47023	28
627	.27847	328	.61417	035	.00869	748	.47881	29
.76655	3.28366	.78356	3.62023	.80063	4.01585	.81776	4.48740	30
684	.28885	384	.62630	092	.02303	805	.49603	31
712	.29406	413	.63238	120	.03024	834	.50468	32
740	.29929	441	.63849	149	.03746	862	.51337	33
769	.30452	470	.64461	177	.04471	891	.52208	34
.76797	3.30977	.78498	3.65074	.80206	4.05197	.81919	4.53081	35
825	.31503	526	.65690	234	.05926	948	.53958	36
854	.32031	555	.66307	263	.06657	977	.54837	37
882	.32560	583	.66925	291	.07390	.82005	.55720	38
910	.33090	612	.67545	320	.08125	034	.56605	39
.76938	3.33622	.78640	3.68167	.80348	4.08863	.82063	4.57493	40
967	.34154	669	.68791	377	.09602	091	.58383	41
995	.34689	697	.69417	405	.10344	120	.59277	42
.77023	.35224	725	.70044	434	.11088	148	.60174	43
052	.35761	754	.70673	462	.11835	177	.61073	44
.77080	3.36299	.78782	3.71303	.80491	4.12583	.82206	4.61976	45
108	.36839	811	.71935	519	.13334	234	.62881	46
137	.37380	839	.72569	548	.14087	263	.63790	47
165	.37923	868	.73205	577	.14842	292	.64701	48
193	.38466	896	.73843	605	.15599	320	.65616	49
.77222	3.39012	.78924	3.74482	.80634	4.16359	.82349	4.66533	50
250	.39558	953	.75123	662	.17121	377	.67454	51
278	.40106	981	.75766	691	.17886	406	.68377	52
307	.40656	.79010	.76411	719	.18652	435	.69304	53
335	.41206	038	.77057	748	.19421	463	.70234	54
.77363	3.41759	.79067	3.77705	.80776	4.20193	.82492	4.71166	55
392	.42312	095	.78355	805	.20966	521	.72102	56
420	.42867	123	.79007	833	.21742	549	.73041	57
448	.43424	152	.79661	862	.22521	578	.73983	58
477	.43982	180	.80316	891	.23301	607	.74928	59
.77505	3.44541	.79209	3.80973	.80919	4.24084	.82635	4.75877	60

M.	80°		81°		82°		8
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	Vers.
0	.82635	4.75877	.84357	5.39245	.86083	6.18530	.87813
1	664	.76829	385	.40422	111	.20020	842
2	692	.77783	414	.41602	140	.21517	871
3	721	.78742	443	.42787	169	.23019	900
4	750	.79703	471	.43977	198	.24529	929
5	.82778	4.80667	.84500	5.45171	.86227	6.26044	.87957
6	807	.81635	529	.46369	256	.27566	986
7	836	.82606	558	.47572	284	.29095	.88015
8	864	.83581	586	.48779	313	.30630	044
9	893	.84558	615	.49991	342	.32171	073
10	.82922	4.85539	.84644	5.51208	.86371	6.33719	.88102
11	950	.86524	673	.52429	400	.35274	131
12	979	.87511	701	.53655	428	.36835	160
13	.83008	.88502	730	.54886	457	.38403	188
14	036	.89497	759	.56121	486	.39978	217
15	.83065	4.90495	.84788	5.57361	.86515	6.41560	.88246
16	094	.91496	816	.58606	544	.43148	275
17	122	.92501	845	.59855	573	.44743	304
18	151	.93509	874	.61110	601	.46346	333
19	180	.94521	903	.62369	630	.47955	362
20	.83208	4.95536	.84931	5.63633	.86659	6.49571	.88391
21	237	.96555	960	.64902	688	.51194	420
22	266	.97577	989	.66176	717	.52825	448
23	294	.98603	.85018	.67454	746	.54462	477
24	323	.99633	046	.68738	774	.56107	506
25	.83352	5.00666	.85075	5.70027	.86803	6.57759	.88535
26	380	.01702	104	.71321	832	.59418	564
27	409	.02743	133	.72620	861	.61085	593
28	438	.03787	162	.73924	890	.62759	622
29	467	.04834	190	.75233	919	.64441	651
30	.83495	5.05886	.85219	5.76547	.86947	6.66130	.88680
31	524	.06941	248	.77866	976	.67826	709
32	553	.08000	277	.79191	.87005	.69530	737
33	581	.09062	305	.80521	034	.71242	766
34	610	.10129	334	.81856	063	.72962	795
35	.83639	5.11199	.85363	5.83196	.87092	6.74689	.88824
36	667	.12273	392	.84542	120	.76424	853
37	696	.13350	420	.85893	149	.78167	882
38	725	.14432	449	.87250	178	.79918	911
39	754	.15517	478	.88612	207	.81677	940
40	.83782	5.16607	.85507	5.89979	.87236	6.83443	.88969
41	811	.17700	536	.91352	265	.85218	998
42	840	.18797	564	.92731	294	.87001	.89027
43	868	.19898	593	.94115	322	.88792	055
44	897	.21004	622	.95505	351	.90592	084
45	.83926	5.22113	.85651	5.96900	.87380	6.92399	.89113
46	954	.23226	680	.98301	409	.94216	142
47	983	.24343	708	.99708	438	.96040	171
48	.84012	.25464	737	6.01120	467	.97873	200
49	041	.26590	766	.02538	496	.99714	229
50	.84069	5.27719	.85795	6.03962	.87524	7.01565	.89258
51	098	.28853	823	.05392	553	.03423	287
52	127	.29991	852	.06828	582	.05291	316
53	155	.31133	881	.08269	611	.07167	345
54	184	.32279	910	.09717	640	.09052	374
55	.84213	5.33429	.85939	6.11171	.87669	7.10946	.89403
56	242	.34584	967	.12630	698	.12849	431
57	270	.35743	996	.14096	726	.14760	460
58	299	.36906	.86025	.15568	755	.16681	489
59	328	.38073	054	.17046	784	.18612	518
60	.84357	5.39245	.86083	6.18530	.87813	7.20551	.89547

84°		85°		86°		M.
Vers.	Exsec.	Vers.	Exsec.	Vers.	Exsec.	
.89547	8.56677	.91284	10.47371	.93024	13.33559	0
576	.59332	313	.51199	053	.39547	1
605	.62002	342	.55052	082	.45586	2
634	.64687	371	.58932	111	.51676	3
663	.67387	400	.62837	140	.57817	4
.89692	8.70103	.91429	10.66769	.93169	13.64011	5
721	.72833	458	.70728	198	.70258	6
750	.75579	487	.74714	227	.76558	7
779	.78341	516	.78727	257	.82913	8
808	.81119	545	.82768	286	.89323	9
.89836	8.83912	.91574	10.86837	.93315	13.95788	10
865	.86722	603	.90934	344	14.02310	11
894	.89547	632	.95060	373	.08890	12
923	.92389	661	.99214	402	.15527	13
952	.95248	690	11.03397	431	.22223	14
.89981	8.98123	.91719	11.07610	.93460	14.28979	15
.90010	9.01015	748	.11852	489	.35795	16
039	.03923	777	.16125	518	.42672	17
068	.06849	806	.20427	547	.49611	18
097	.09792	835	.24761	576	.56613	19
.90126	9.12752	.91864	11.29125	.93605	14.63679	20
155	.15730	893	.33521	634	.70810	21
184	.18725	922	.37948	663	.78005	22
213	.21739	951	.42408	692	.85268	23
242	.24770	980	.46900	721	.92597	24
.90271	9.27819	.92009	11.51424	.93750	14.99995	25
300	.30887	038	.55981	779	15.07462	26
329	.33973	067	.60572	808	.14999	27
358	.37077	096	.65197	837	.22607	28
386	.40201	125	.69856	866	.30287	29
.90415	9.43343	.92154	11.74549	.93895	15.38041	30
444	.46505	183	.79278	924	.45869	31
473	.49685	212	.84042	953	.53772	32
502	.52886	241	.88841	982	.61751	33
531	.56106	270	.93677	.94011	.69808	34
.90560	9.59346	.92299	11.98549	.94040	15.77944	35
589	.62605	328	12.03458	069	.86159	36
618	.65885	357	.08404	098	.94456	37
647	.69186	386	.13388	127	16.02835	38
676	.72507	415	.18411	156	.11297	39
.90705	9.75849	.92444	12.23472	.94186	16.19843	40
734	.79212	473	.28572	215	.28476	41
763	.82596	502	.33712	244	.37196	42
792	.86001	531	.38891	273	.46005	43
821	.89428	560	.44112	302	.54903	44
.90850	9.92877	.92589	12.49373	.94331	16.63893	45
879	.96348	618	.54676	360	.72975	46
908	.99841	647	.60021	389	.82152	47
937	10.03356	676	.65408	418	.91424	48
966	.06894	705	.70838	447	17.00794	49
.90995	10.10455	.92734	12.76311	.94476	17.10262	50
.91024	.14039	763	.81829	505	.19830	51
053	.17646	792	.87391	534	.29500	52
082	.21277	821	.92999	563	.39274	53
111	.24932	850	.98651	592	.49153	54
.91140	10.28610	.92879	13.04350	.94621	17.59139	55
169	.32313	908	.10096	650	.69233	56
197	.36040	937	.15889	679	.79438	57
226	.39792	966	.21730	708	.897[illegible]	58
255	.43569	995	.27620	737	18.00185	59
.91284	10.47371	.93024	13.33559	.94766	18.10732	60

M.	87°		88°		89°	
	Vers.	Exsec.	Vers.	Exsec.	Vers.	Ex
0	.94766	18. 10732	.96510	27. 65371	.98255	56.
1	795	.21397	539	.89440	284	57.
2	825	.32182	568	28. 13917	313	58.
3	854	.43088	597	.38812	342	59.
4	883	.54119	626	.64137	371	60.
5	.94912	18. 65275	.96655	28. 89903	.98400	61.
6	941	.76560	684	29. 16120	429	62.
7	970	.87976	714	.42802	458	63.
8	999	.99524	743	.69960	487	65.
9	.95028	19. 11207	772	.97607	517	66.
10	.95057	19. 23028	.96801	30. 25758	.98546	67.
11	086	.34989	830	.54425	575	69.
12	115	.47093	859	.83623	604	70.
13	144	.59341	888	31. 13366	633	72.
14	173	.71737	917	.43671	662	73.
15	.95202	19. 84283	.96946	31. 74554	.98691	75.
16	231	.96982	975	32. 06030	720	77.
17	260	20. 09838	.97004	.38118	749	78.
18	289	.22852	033	.70835	778	80.
19	318	.36027	062	33. 04199	807	82.
20	.95347	20. 49368	.97092	33. 38232	.98836	84.
21	377	.62876	121	.72951	866	87.
22	406	.76555	150	34. 08380	895	89.
23	435	.90409	179	.44539	924	91.
24	464	21. 04440	208	.81452	953	94.
25	.95493	21. 18653	.97237	35. 19141	.98982	97.
26	522	.33050	266	.57633	.99011	100.
27	551	.47635	295	.96953	040	103.
28	580	.62413	324	36. 37127	069	106.
29	609	.77386	353	.78185	098	109.
30	.95638	21. 92559	.97382	37. 20155	.99127	113.
31	667	22. 07935	411	.63068	156	117.
32	696	.23520	440	38. 06957	186	121.
33	725	.39316	470	.51855	215	126.
34	754	.55329	499	.97797	244	131.
35	.95783	22. 71563	.97528	39. 44820	.99273	136.
36	812	.88022	557	.92963	302	142.
37	841	23. 04712	586	40. 42266	331	148.
38	871	.21637	615	.92772	360	155.
39	900	.38802	644	41. 44525	389	162.
40	.95929	23. 56212	.97673	41. 97571	.99418	170.
41	958	.73873	702	42. 51961	447	179.
42	987	.91790	731	43. 07746	476	189.
43	.96016	24. 09969	760	.64980	505	201.
44	045	.28414	789	44. 23719	535	213.
45	.96074	24. 47134	.97819	44. 84026	.99564	228.
46	103	.66132	848	45. 45963	593	244.
47	132	.85417	877	46. 09596	622	263.
48	161	25. 04994	906	.74997	651	285.
49	190	.24869	935	47. 42241	680	311.
50	.96219	25. 45051	.97964	48. 11406	.99709	342.
51	248	.65545	993	.82576	738	380.
52	277	.86360	.98022	49. 55840	767	428.
53	307	26. 07503	051	50. 31290	796	490.
54	336	.28981	080	51. 09027	825	571.
55	.96365	26. 50804	.98109	51. 89156	.99855	686.
56	394	.72978	138	52. 71790	884	858.
57	423	.95512	168	53. 57046	913	1144.
58	452	27. 18417	197	54. 45953	942	1717.
59	481	.41700	226	55. 38946	971	3435
60	.96510	27. 65371	.98255	56. 29869	1. 00000	

TABLE XX.—LENGTHS OF CIRCULAR ARCS; RADIUS=I.

Length.	Min.	Length.	Deg.	Length.	Deg.	Length.
.0000048	1	.0002909	1	.0174533	61	1.0646508
00097	2	05818	2	.0349066	62	.0821041
00145	3	08727	3	.0523599	63	.0995574
00194	4	11636	4	.0698132	64	.1170107
.0000242	5	.0014544	5	.0872665	65	1.1344640
00291	6	17453	6	.1047198	66	.1519173
00339	7	20362	7	.1221730	67	.1693706
00388	8	23271	8	.1396263	68	.1868239
00436	9	26180	9	.1570796	69	.2042772
.0000485	10	.0029089	10	.1745329	70	1.2217305
00533	11	31998	11	.1919862	71	.2391838
00582	12	34907	12	.2094395	72	.2566371
00630	13	37815	13	.2268928	73	.2740904
00679	14	40724	14	.2443461	74	.2915436
.0000727	15	.0043633	15	.2617994	75	1.3089969
00776	16	46542	16	.2792527	76	.3264502
00824	17	49451	17	.2967060	77	.3439035
00873	18	52360	18	.3141593	78	.3613568
00921	19	55269	19	.3316126	79	.3788101
.0000970	20	.0058178	20	.3490659	80	1.3962634
01018	21	61087	21	.3665191	81	.4137167
01067	22	63995	22	.3839724	82	.4311700
01115	23	66904	23	.4014257	83	.4486233
01164	24	69813	24	.4188790	84	.4660766
.0001212	25	.0072722	25	.4363323	85	1.4835298
01261	26	75631	26	.4537856	86	.5009832
01309	27	78540	27	.4712389	87	.5184364
01357	28	81449	28	.4886922	88	.5358897
01406	29	84358	29	.5061455	89	.5533430
.0001454	30	.0087266	30	.5235988	90	1.5707963
01503	31	90175	31	.5410521	91	.5882496
01551	32	93084	32	.5585054	92	.6057029
01600	33	95993	33	.5759587	93	.6231562
01648	34	98902	34	.5934119	94	.6406095
.0001697	35	.0101811	35	.6108652	95	1.6580628
01745	36	04720	36	.6283185	96	.6755161
01794	37	07629	37	.6457718	97	.6929694
01842	38	10538	38	.6632251	98	.7104227
01891	39	13446	39	.6806784	99	.7278760
.0001939	40	.0116355	40	.6981317	100	1.7453293
01988	41	19264	41	.7155850	101	.7627825
02036	42	22173	42	.7330383	102	.7802358
02085	43	25082	43	.7504916	103	.7976891
02133	44	27991	44	.7679449	104	.8151424
.0002182	45	.0130900	45	.7853982	105	1.8325957
02230	46	33809	46	.8028515	106	.8500490
02279	47	36717	47	.8203047	107	.8675023
02327	48	39626	48	.8377580	108	.8849556
02376	49	42535	49	.8552113	109	.9024089
.0002424	50	.0145444	50	.8726646	110	1.9198622
02473	51	48353	51	.8901179	111	.9373155
02521	52	51262	52	.9075712	112	.9547688
02570	53	54171	53	.9250245	113	.9722221
02618	54	57080	54	.9424778	114	.9896753
.0002666	55	.0159989	55	.9599311	115	2.0071286
02715	56	62897	56	.9773844	116	.0245819
02763	57	65806	57	.9948377	117	.0420352
02812	58	68715	58	1.0122910	118	.0594885
02860	59	71624	59	1.0297443	119	.0769418
.0002909	60	.0174533	60	1.0471976	120	2.0943951

Min.	1°	2°	3°	4°	5°	6°
0	.000000	.000002	.000006	.000014	.000028	.000048
1	000	002	006	014	028	048
2	000	002	006	015	028	049
3	000	002	006	015	029	049
4	000	002	006	015	029	049
5	.000000	.000002	.000006	.000015	.000029	.000050
6	000	002	007	015	029	050
7	000	002	007	015	030	051
8	000	002	007	016	030	051
9	000	002	007	016	030	052
10	.000000	.000002	.000007	.000016	.000031	.000052
11	000	002	007	016	031	052
12	000	002	007	016	031	053
13	000	002	007	017	031	053
14	000	002	007	017	032	054
15	.000000	.000003	.000008	.000017	.000032	.000054
16	000	003	008	017	032	055
17	000	003	008	017	033	055
18	000	003	008	018	033	055
19	001	003	008	018	033	056
20	.000001	.000003	.000008	.000018	.000034	.000056
21	001	003	008	018	034	057
22	001	003	008	018	034	057
23	001	003	009	019	035	058
24	001	003	009	019	035	058
25	.000001	.000003	.000009	.000019	.000035	.000059
26	001	003	009	019	036	059
27	001	003	009	020	036	059
28	001	003	009	020	036	060
29	001	003	009	020	037	060
30	.000001	.000003	.000009	.000020	.000037	.000061
31	001	004	010	020	037	061
32	001	004	010	021	038	062
33	001	004	010	021	038	062
34	001	004	010	021	038	063
35	.000001	.000004	.000010	.000021	.000039	.000063
36	001	004	010	022	039	064
37	001	004	010	022	039	064
38	001	004	011	022	040	065
39	001	004	011	022	040	065
40	.000001	.000004	.000011	.000023	.000040	.000066
41	001	004	011	023	041	066
42	001	004	011	023	041	067
43	001	004	011	023	041	067
44	001	005	012	023	042	068
45	.000001	.000005	.000012	.000024	.000042	.000068
46	001	005	012	024	043	069
47	001	005	012	024	043	069
48	001	005	012	024	043	070
49	001	005	012	025	044	070
50	.000001	.000005	.000012	.000025	.000044	.000071
51	001	005	013	025	044	071
52	001	005	013	026	045	072
53	001	005	013	026	045	072
54	002	005	013	026	045	073
55	.000002	.000005	.000013	.000026	.000046	.000073
56	002	006	013	027	046	074
57	002	006	014	027	047	074
58	002	006	014	027	047	075
59	002	006	014	027	047	075
60	.000002	.000006	.000014	.000028	.000048	.000076
Min.	1°	2°	3°	4°	5°	6°

8°	9°	10°	11°	12°	13°	14°	Min.
.000113	.000161	.000221	.000295	.000383	.000486	.000607	0
114	162	223	296	384	488	610	1
115	163	224	297	386	490	612	2
116	164	225	299	387	492	614	3
116	165	226	300	389	494	616	4
.000117	.000166	.000227	.000301	.000391	.000496	.000618	5
118	167	228	303	392	498	621	6
118	168	229	304	394	500	623	7
119	169	230	306	395	501	625	8
120	170	232	307	397	503	627	9
.000121	.000171	.000233	.000308	.000399	.000505	.000629	10
121	172	234	310	400	507	632	11
122	172	235	311	402	509	634	12
123	173	236	312	404	511	636	13
124	174	237	314	405	513	638	14
.000124	.000175	.000238	.000315	.000407	.000515	.000641	15
125	176	240	317	409	517	643	16
126	177	241	318	410	519	645	17
127	178	242	319	412	521	647	18
127	179	243	321	414	523	650	19
.000128	.000180	.000244	.000322	.000415	.000525	.000652	20
129	181	246	324	417	527	654	21
130	182	247	325	419	529	656	22
130	183	248	327	420	531	659	23
131	184	249	328	422	533	661	24
.000132	.000185	.000250	.000329	.000424	.000535	.000663	25
133	186	251	331	426	537	666	26
134	187	253	332	427	539	668	27
134	188	254	334	429	541	670	28
135	189	255	335	431	543	672	29
.000136	.000190	.000256	.000337	.000432	.000545	.000675	30
137	191	258	338	434	547	677	31
138	192	259	340	436	549	679	32
138	193	260	341	438	551	682	33
139	194	261	343	439	553	684	34
.000140	.000195	.000262	.000344	.000441	.000555	.000686	35
141	196	264	346	443	557	689	36
142	197	265	347	445	559	691	37
143	198	266	349	446	561	694	38
143	199	267	350	448	563	696	39
.000144	.000200	.000269	.000352	.000450	.000565	.000698	40
145	201	270	353	452	567	701	41
146	202	271	355	453	569	703	42
147	203	273	356	455	571	705	43
148	204	274	358	457	573	708	44
.000148	.000205	.000275	.000359	.000459	.000575	.000710	45
149	206	276	361	461	578	713	46
150	207	278	362	462	580	715	47
151	208	279	364	464	582	718	48
152	209	280	365	466	584	720	49
.000153	.000211	.000282	.000367	.000468	.000586	.000722	50
154	212	283	368	470	588	725	51
154	213	284	370	472	590	727	52
155	214	285	372	473	592	730	53
156	215	287	373	475	594	732	54
.000157	.000216	.000288	.000375	.000477	.000597	.000735	55
158	217	289	376	479	599	737	56
159	218	291	378	481	601	740	57
160	219	292	379	483	603	742	58
161	220	293	381	485	605	745	59
.000161	.000221	.000295	.000383	.000486	.000607	.000747	60
8°	9°	10°	11°	12°	13°	14°	Min.

Min.	15°	16°	17°	18°	19°	20°	21°
0	.000747	.000906	.001087	.001290	.001517	.001767	.002048
1	750	909	090	294	521	774	053
2	752	912	094	298	525	778	058
3	755	915	097	301	529	783	063
4	757	918	100	305	533	787	068
5	.000760	.000921	.001103	.001308	.001537	.001792	.002073
6	762	924	106	312	541	796	077
7	765	926	110	316	545	801	082
8	767	929	113	319	549	805	087
9	770	932	116	323	554	810	092
10	.000772	.000935	.001119	.001326	.001558	.001814	.002097
11	775	938	123	330	562	819	102
12	777	941	126	334	566	823	107
13	780	944	129	337	570	828	112
14	782	947	132	341	574	832	117
15	.000785	.000950	.001136	.001345	.001578	.001837	.002122
16	788	953	139	348	582	841	127
17	790	955	142	352	586	846	132
18	793	958	146	356	590	850	137
19	795	961	149	360	594	855	142
20	.000798	.000964	.001152	.001363	.001599	.001859	.002147
21	800	967	156	367	603	864	152
22	803	970	159	371	607	869	157
23	806	973	162	374	611	873	162
24	808	976	166	378	615	878	167
25	.000811	.000979	.001169	.001382	.001619	.001882	.002172
26	814	982	172	386	623	887	177
27	816	985	176	389	628	892	182
28	819	988	179	393	632	896	188
29	822	991	182	397	636	901	193
30	.000824	.000994	.001186	.001401	.001640	.001905	.002198
31	827	997	189	405	644	910	203
32	830	.001000	193	408	649	915	208
33	832	003	196	412	653	919	213
34	835	006	199	416	657	924	218
35	.000838	.001009	.001203	.001420	.001661	.001929	.002223
36	840	012	206	424	666	933	228
37	843	015	210	427	670	938	234
38	846	018	213	431	674	943	239
39	848	021	217	435	678	948	244
40	.000851	.001024	.001220	.001439	.001683	.001952	.002249
41	854	028	223	443	687	957	254
42	856	031	227	447	691	962	260
43	859	034	230	451	695	966	265
44	862	037	234	454	700	971	270
45	.000865	.001040	.001237	.001458	.001704	.001976	.002275
46	867	043	241	462	708	981	280
47	870	046	244	466	713	985	286
48	873	049	248	470	717	990	291
49	876	052	251	474	721	995	296
50	.000878	.001056	.001255	.001478	.001726	.002000	.002301
51	881	059	258	482	730	005	307
52	884	062	262	486	734	009	312
53	887	065	265	490	739	014	317
54	890	068	269	494	743	019	323
55	.000892	.001071	.001273	.001497	.001747	.002024	.002328
56	895	074	276	501	752	029	333
57	898	078	280	505	756	034	338
58	901	081	283	509	761	038	344
59	904	084	287	513	765	043	349
60	.000906	.001087	.001290	.001517	.001769	.002048	.002355
Min.	15°	16°	17°	18°	19°	20°	21°

22°	23°	24°	25°	26°	27°	28°	Min.
.002354	.002690	.003056	.003453	.003883	.004348	.004848	0
360	696	062	460	891	356	857	1
365	702	068	467	898	364	866	2
371	707	075	474	906	372	874	3
376	713	081	481	913	380	883	4
.002381	.002719	.003088	.003488	.003921	.004388	.004892	5
387	725	094	495	928	397	900	6
392	731	100	502	936	405	909	7
397	737	107	509	943	413	918	8
403	743	113	516	951	421	927	9
.002408	.002749	.003120	.003523	.003959	.004429	.004935	10
414	755	126	530	966	437	944	11
419	761	133	537	974	445	953	12
425	766	139	544	981	453	962	13
430	772	146	551	989	462	970	14
.002436	.002778	.003152	.003558	.003996	.004470	.004979	15
441	784	158	565	.004004	478	988	16
447	790	165	572	012	486	997	17
452	796	171	579	019	494	.005006	18
457	802	178	586	027	503	014	19
.002463	.002808	.003185	.003593	.004035	.004511	.005023	20
468	814	191	600	042	519	032	21
474	820	198	607	050	527	041	22
480	826	204	614	057	536	050	23
485	832	211	621	065	544	059	24
.002491	.002838	.003217	.003628	.004073	.004552	.005068	25
496	845	224	635	081	561	077	26
502	851	230	643	088	569	085	27
507	857	237	650	096	577	094	28
513	863	244	657	104	585	103	29
.002518	.002869	.003250	.003664	.004111	.004594	.005112	30
524	875	257	671	119	602	121	31
530	881	264	678	127	610	130	32
535	887	270	686	135	619	139	33
541	893	277	693	143	627	148	34
.002546	.002899	.003284	.003700	.004150	.004636	.005157	35
552	906	290	707	158	644	166	36
558	912	297	715	166	652	175	37
563	918	304	722	174	661	184	38
569	924	310	729	182	669	193	39
.002575	.002930	.003317	.003736	.004189	.004678	.005202	40
580	936	324	744	197	686	211	41
586	943	330	751	205	695	220	42
592	949	337	758	213	703	229	43
597	955	344	765	221	711	239	44
.002603	.002961	.003351	.003773	.004229	.004720	.005248	45
609	968	357	780	237	728	257	46
615	974	364	787	245	737	266	47
620	980	371	795	252	745	275	48
626	986	378	802	260	754	284	49
.002632	.002993	.003385	.003809	.004268	.004763	.005293	50
638	999	391	817	276	771	303	51
643	.003005	398	824	284	780	312	52
649	011	405	831	292	788	321	53
655	018	412	839	300	797	330	54
.002661	.003024	.003419	.003846	.004308	.004805	.005339	55
667	030	426	854	316	814	349	56
672	037	432	861	324	823	358	57
678	043	439	869	332	831	367	58
684	049	446	876	340	840	376	59
.002690	.003056	.003453	.003883	.004348	.004848	.005385	60
22°	23°	24°	25°	26°	27°	28°	Min

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipr cals.
1	1	1	1.0000000	1.0000000	1.00000
2	4	8	.4142136	.2599210	.50000
3	9	27	.7320508	.4422496	.33333
4	16	64	2.0000000	.5874011	.25000
5	25	125	2.2360680	1.7099759	.20000
6	36	216	.4494897	.8171206	.16666
7	49	343	.6457513	.9129312	.14285
8	64	512	.8284271	2.0000000	.12500
9	81	729	3.0000000	.0800837	.11111
10	100	1000	3.1622777	2.1544347	.10000
11	121	1331	.3166248	.2239801	.09090
12	144	1728	.4641016	.2894286	.08333
13	169	2197	.6055513	.3513347	.07692
14	196	2744	.7416574	.4101422	142
15	225	3375	3.8729833	2.4662121	.06666
16	256	4096	4.0000000	.5198421	250
17	289	4913	.1231056	.5712816	.05882
18	324	5832	.2426407	.6207414	555
19	361	6859	.3588989	.6684016	263
20	400	8000	4.4721360	2.7144177	.05000
21	441	9261	.5825757	.7589243	.04761
22	484	10648	.6904158	.8020393	545
23	529	12167	.7958315	.8438670	347
24	576	13824	.8989795	.8844991	166
25	625	15625	5.0000000	2.9240177	.04000
26	676	17576	.0990195	.9624960	.03846
27	729	19683	.1961524	3.0000000	703
28	784	21952	.2915026	.0365889	571
29	841	24389	.3851648	.0723168	448
30	900	27000	5.4772256	3.1072325	.03333
31	961	29791	.5677644	.1413806	225
32	1024	32768	.6568542	.1748021	125
33	1089	35937	.7445626	.2075343	030
34	1156	39304	.8309519	.2396118	.02941
35	1225	42875	5.9160798	3.2710663	.02857
36	1296	46656	6.0000000	.3019272	777
37	1369	50653	.0827625	.3322218	702
38	1444	54872	.1644140	.3619754	631
39	1521	59319	.2449980	.3912114	564
40	1600	64000	6.3245553	3.4199519	.02500
41	1681	68921	.4031242	.4482172	439
42	1764	74088	.4807407	.4760266	380
43	1849	79507	.5574385	.5033981	325
44	1936	85184	.6332496	.5303483	272
45	2025	91125	6.7082039	3.5568933	.02222
46	2116	97336	.7823300	.5830479	173
47	2209	103823	.8556546	.6088261	127
48	2304	110592	.9282032	.6342411	083
49	2401	117649	7.0000000	.6593057	040
50	2500	125000	7.0710678	3.6840314	.02000
51	2601	132651	.1414284	.7084298	.01960
52	2704	140608	.2111026	.7325111	923
53	2809	148877	.2801099	.7562858	886
54	2916	157464	.3484692	.7797631	851
55	3025	166375	7.4161985	3.8029525	.01818
56	3136	175616	.4833148	.8258624	785
57	3249	185193	.5498344	.8485011	754
58	3364	195112	.6157731	.8708766	72
59	3481	205379	.6811457	.8929965	6

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.	No.
3600	216000	7.7459667	3.9148676	.016666667	60
3721	226981	.8102497	.9364972	6393443	61
3844	238328	.8740079	.9578915	6129032	62
3969	250047	.9372539	.9790571	5873016	63
4096	262144	8.0000000	4.0000000	5625000	64
4225	274625	8.0622577	4.0207256	.015384615	65
4356	287496	.1240384	.0412401	5151515	66
4489	300763	.1853528	.0615480	4925373	67
4624	314432	.2462113	.0816551	4705882	68
4761	328509	.3066239	.1015661	4492754	69
4900	343000	8.3666003	4.1212853	.014285714	70
5041	357911	.4261498	.1408178	4084507	71
5184	373248	.4852814	.1601676	3888889	72
5329	389017	.5440037	.1793392	3698630	73
5476	405224	.6023253	.1983364	3513514	74
5625	421875	8.6602540	4.2171633	.013333333	75
5776	438976	.7177979	.2358236	3157895	76
5929	456533	.7749644	.2543210	2987013	77
6084	474552	.8317609	.2726586	2820513	78
.6241	493039	.8881944	.2908404	2658228	.79
6400	512000	8.9442719	4.3088695	.012500000	80
6561	531441	9.0000000	.3267487	2345679	81
6724	551368	.0553851	.3444815	2195122	82
6889	571787	.1104336	.3620707	2048193	83
7056	592704	.1651514	.3795191	1904762	84
7225	614125	9.2195445	4.3968296	.011764706	85
7396	636056	.2736185	.4140049	1627907	86
7569	658503	.3273791	.4310476	1494253	87
7744	681472	.3808315	.4479602	1363636	88
7921	704969	.4339811	.4647451	1235955	89
8100	729000	9.4868330	4.4814047	.011111111	90
8281	753571	.5393920	.4979414	0989011	91
8464	778688	.5916630	.5143574	0869565	92
8649	804357	.6436508	.5306549	0752688	93
8836	830584	.6953597	.5468359	0638298	94
9025	857375	9.7467943	4.5629026	.010526316	95
9216	884736	.7979590	.5788570	0416667	96
9409	912673	.8488578	.5947009	0309278	97
9604	941192	.8994949	.6104363	0204082	98
9801	970299	.9498744	.6260650	0101010	99
10000	1000000	10.0000000	4.6415888	.010000000	100
10201	1030301	.0498756	.6570095	.00990990	101
10404	1061208	.0995049	.6723287	9803922	102
10609	1092727	.1488916	.6875482	9708738	103
10816	1124864	.1980390	.7026694	9615385	104
11025	1157625	10.2469508	4.7176940	.009523810	105
11236	1191016	.2956301	.7326235	9433962	106
11449	1225043	.3440804	.7474594	9345794	107
11664	1259712	.3923048	.7622032	9259259	108
11881	1295029	.4403065	.7768562	9174312	109
12100	1331000	10.4880885	4.7914199	.00909090	110
12321	1367631	.5356538	.8058955	0090090	111
12544	1404928	.5830052	.8202845	8928571	112
12769	1442897	.6301458	.8345881	8849558	113
12996	1481544	.6770783	.8488076	8771930	114
13225	1520875	10.7238053	4.8629442	.008695652	115
13456	1560896	.7703296	.8769990	8620690	116
13689	1601613	.8166538	.8909732	8547009	117
13924	1643032	.8627805	.9048681	8474576	118
14161	1685159	.9087121	.9186847	8403361	119

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
120	14400	1728000	10.9544512	4.9324242	.008333333
121	14641	1771561	11.0000000	.9460874	8264463
122	14884	1815848	.0453610	.9596757	8196721
123	15129	1860867	.0905365	.9731898	8130081
124	15376	1906624	.1355287	.9866310	8064516
125	15625	1953125	11.1803399	5.0000000	.008000000
126	15876	2000376	.2249722	.0132979	7936508
127	16129	2048383	.2694277	.0265257	7874016
128	16384	2097152	.3137085	.0396842	7812500
129	16641	2146689	.3578167	.0527743	7751938
130	16900	2197000	11.4017543	5.0657970	.007692308
131	17161	2248091	.4455231	.0787531	7633588
132	17424	2299968	.4891253	.0916434	7575758
133	17689	2352637	.5325626	.1044687	7518797
134	17956	2406104	.5758369	.1172299	7462687
135	18225	2460375	11.6189500	5.1299278	.007407407
136	18496	2515456	.6619038	.1425632	7352941
137	18769	2571353	.7046999	.1551367	7299270
138	19044	2628072	.7473401	.1676493	7246377
139	19321	2685619	.7898261	.1801015	7194245
140	19600	2744000	11.8321596	5.1924941	.007142857
141	19881	2803221	.8743421	.2048279	7092199
142	20164	2863288	.9163753	.2171034	7042254
143	20449	2924207	.9582607	.2293215	6993007
144	20736	2985984	12.0000000	.2414828	6944444
145	21025	3048625	12.0415946	5.2535879	.006896552
146	21316	3112136	.0830460	.2656374	6849315
147	21609	3176523	.1243557	.2776321	6802721
148	21904	3241792	.1655251	.2895725	6756757
149	22201	3307949	.2065556	.3014592	6711409
150	22500	3375000	12.2474487	5.3132928	.006666667
151	22801	3442951	.2882057	.3250740	6622517
152	23104	3511808	.3288280	.3368033	6578947
153	23409	3581577	.3693169	.3484812	6535948
154	23716	3652264	.4096736	.3601084	6493506
155	24025	3723875	12.4498996	5.3716854	.006451613
156	24336	3796416	.4899960	.3832126	6410256
157	24649	3869893	.5299641	.3946907	6369427
158	24964	3944312	.5698051	.4061202	6329114
159	25281	4019679	.6095202	.4175015	6289308
160	25600	4096000	12.6491106	5.4288352	.006250000
161	25921	4173281	.6885775	.4401218	6211180
162	26244	4251528	.7279221	.4513618	6172840
163	26569	4330747	.7671453	.4625556	6134969
164	26896	4410944	.8062485	.4737037	6097561
165	27225	4492125	12.8452326	5.4848066	.006060606
166	27556	4574296	.8840987	.4958647	6024096
167	27889	4657463	.9228480	.5068784	5988024
168	28224	4741632	.9614814	.5178484	5952381
169	28561	4826809	13.0000000	.5287748	5917160
170	28900	4913000	13.0384048	5.5396583	.005882353
171	29241	5000211	.0766968	.5504991	5847953
172	29584	5088448	.1148770	.5612978	5813953
173	29929	5177717	.1529464	.5720546	5780347
174	30276	5268024	.1909060	.5827702	5747126
175	30625	5359375	13.2287566	5.5934447	.005714286
176	30976	5451776	.2664992	.6040787	5681818
177	31329	5545233	.3041347	.6145724	5649718
178	31684	5639752	.3416641	.6252263	5617978
179	32041	5735339	.3790882	.6357408	5586592

Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.	No.
32400	5832000	13.4164079	5.6462162	.005555556	180
32761	5929741	.4536240	.6566528	5524862	181
33124	6028568	.4907376	.6670511	5494505	182
33489	6128487	.5277493	.6774114	5464481	183
33856	6229504	.5646600	.6877340	5434783	184
34225	6331625	13.6014705	5.6980192	.005405405	185
34596	6434856	.6381817	.7082675	5376344	186
34969	6539203	.6747943	.7184791	5347594	187
35344	6644672	.7113092	.7286543	5319149	188
35721	6751269	.7477271	.7387936	5291005	189
36100	6859000	13.7840488	5.7488971	.005263158	190
36481	6967871	.8202750	.7589652	5235602	191
36864	7077888	.8564065	.7689982	5208333	192
37249	7189057	.8924440	.7789966	5181347	193
37636	7301384	.9283883	.7889604	5154639	194
38025	7414875	13.9642400	5.7988900	.005128205	195
38416	7529536	14.0000000	.8087857	5102041	196
38809	7645373	.0356688	.8186479	5076142	197
39204	7762392	.0712473	.8284767	5050505	198
39601	7880599	.1067360	.8382725	5025126	199
40000	8000000	14.1421356	5.8480355	.005000000	200
40401	8120601	.1774469	.8577660	4975124	201
40804	8242408	.2126704	.8674643	4950495	202
41209	8365427	.2478068	.8771307	4926108	203
41616	8489664	.2828569	.8867653	4901961	204
42025	8615125	14.3178211	5.8963685	.004878049	205
42436	8741816	.3527001	.9059406	4854369	206
42849	8869743	.3874946	.9154817	4830918	207
43264	8998912	.4222051	.9249921	4807692	208
43681	9129329	.4568323	.9344721	4784689	209
44100	9261000	14.4913767	5.9439220	.004761905	210
44521	9393931	.5258390	.9533418	4739336	211
44944	9528128	.5602198	.9627320	4716981	212
45369	9663597	.5945195	.9720926	4694836	213
45796	9800344	.6287388	.9814240	4672897	214
46225	9938375	14.6628783	5.9907264	.004651163	215
46656	10077696	.6969385	6.0000000	4629630	216
47089	10218313	.7309199	.0092450	4608295	217
47524	10360232	.7648231	.0184617	4587156	218
47961	10503459	.7986486	.0276502	4566210	219
48400	10648000	14.8323970	6.0368107	.004545455	220
48841	10793861	.8660687	.0459435	4524887	221
49284	10941048	.8996644	.0550489	4504505	222
49729	11089567	.9331845	.0641270	4484305	223
50176	11239424	.9666295	.0731779	4464286	224
50625	11390625	15.0000000	6.0822020	.004444444	225
51076	11543176	.0332964	.0911994	4424779	226
51529	11697083	.0665192	.1001702	4405286	227
51984	11852352	.0996689	.1091147	4385965	228
52441	12008989	.1327460	.1180332	4366812	229
52900	12167000	15.1657509	6.1269257	.004347826	230
53361	12326391	.1986842	.1357924	4329004	231
53824	12487168	.2315462	.1446337	4310345	232
54289	12649337	.2643375	.1534495	4291845	233
54756	12812904	.2970585	.1622401	4273504	234
55225	12977875	15.3297097	6.1710058	.004255319	235
55696	13144256	.3622915	.1797466	4237288	236
56169	13312053	.3948043	.1884628	4219409	237
56644	13481272	.4272486	.1971544	4201681	238
57121	13651919	.4596248	.2058218	4184100	239

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
240	57600	13824000	15.4919334	6.2144650	.004166667
241	58081	13997521	.5241747	.2230843	4149378
242	58564	14172488	.5563492	.2316797	4132231
243	59049	14348907	.5884573	.2402515	4115226
244	59536	14526784	.6204994	.2487998	4098361
245	60025	14706125	15.6524758	6.2573248	.004081633
246	60516	14886936	.6843871	.2658266	4065041
247	61009	15069223	.7162336	.2743054	4048583
248	61504	15252992	.7480157	.2827613	4032258
249	62001	15438249	.7797338	.2911946	4016064
250	62500	15625000	15.8113883	6.2996053	.004000000
251	63001	15813251	.8429795	.3079935	3984064
252	63504	16003008	.8745079	.3163596	3968254
253	64009	16194277	.9059737	.3247035	3952569
254	64516	16387064	.9373775	.3330256	3937008
255	65025	16581375	15.9687194	6.3413257	.003921569
256	65536	16777216	16.0000000	.3496042	3906250
257	66049	16974593	.0312195	.3578611	3891051
258	66564	17173512	.0623784	.3660968	3875969
259	67081	17373979	.0934769	.3743111	3861004
260	67600	17576000	16.1245155	6.3825043	.003846154
261	68121	17779581	.1554944	.3906765	3831418
262	68644	17984728	.1864141	.3988279	3816794
263	69169	18191447	.2172747	.4069585	3802281
264	69696	18399744	.2480768	.4150687	3787879
265	70225	18609625	16.2788206	6.4231583	.003773585
266	70756	18821096	.3095064	.4312276	3759398
267	71289	19034163	.3401346	.4392767	3745318
268	71824	19248832	.3707055	.4473057	3731343
269	72361	19465109	.4012195	.4553148	3717472
270	72900	19683000	16.4316767	6.4633041	.003703704
271	73441	19902511	.4620776	.4712736	3690037
272	73984	20123648	.4924225	.4792236	3676471
273	74529	20346417	.5227116	.4871541	3663004
274	75076	20570824	.5529454	.4950653	3649635
275	75625	20796875	16.5831240	6.5029572	.003636364
276	76176	21024576	.6132477	.5108300	3623188
277	76729	21253933	.6433170	.5186839	3610108
278	77284	21484952	.6733320	.5265189	3597122
279	77841	21717639	.7032931	.5343351	3584229
280	78400	21952000	16.7332005	6.5421326	.003571429
281	78961	22188041	.7630546	.5499116	3558719
282	79524	22425768	.7928556	.5576722	3546099
283	80089	22665187	.8226038	.5654144	3533569
284	80656	22906304	.8522995	.5731385	3521127
285	81225	23149125	16.8819430	6.5808443	.003508772
286	81796	23393656	.9115345	.5885323	3496503
287	82369	23639903	.9410743	.5962023	3484321
288	82944	23887872	.9705627	.6038545	3472222
289	83521	24137569	17.0000000	.6114890	3460208
290	84100	24389000	17.0293864	6.6191060	.003448276
291	84681	24642171	.0587221	.6267054	3436426
292	85264	24897088	.0880075	.6342874	3424658
293	85849	25153757	.1172428	.6418522	3412969
294	86436	25412184	.1464282	.6493998	3401361
295	87025	25672375	17.1755640	6.6569302	.003389831
296	87616	25934336	.2046505	.6644437	3378378
297	88209	26198073	.2336879	.6719403	3367003
298	88804	26463592	.2626765	.6794200	3355705
299	89401	26730899	.2916165	.6868831	3344482

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.	No.
90000	27000000	17.3205081	6.6943295	.003333333	300
90601	27270901	.3493516	.7017593	3322259	301
91204	27543608	.3781472	.7091729	3311258	302
91809	27818127	.4068952	.7165700	3300330	303
92416	28094464	.4355958	.7239508	3289474	304
93025	28372625	17.4642492	6.7313155	.003278689	305
93636	28652616	.4928557	.7386641	3267974	306
94249	28934443	.5214155	.7459967	3257329	307
94864	29218112	.5499288	.7533134	3246753	308
95481	29503629	.5783958	.7606143	3236246	309
96100	29791000	17.6068169	6.7678995	.003225806	310
96721	30080231	.6351921	.7751690	3215434	311
97344	30371328	.6635217	.7824229	3205128	312
97969	30664297	.6918060	.7896613	3194888	313
98596	30959144	.7200451	.7968844	3184713	314
99225	31255875	17.7482393	6.8040921	.003174603	315
99856	31554496	.7763888	.8112847	3164557	316
100489	31855013	.8044938	.8184620	3154574	317
101124	32157432	.8325545	.8256242	3144654	318
101761	32461759	.8605711	.8327714	3134796	319
102400	32768000	17.8885438	6.8399037	.003125000	320
103041	33076161	.9164729	.8470213	3115265	321
103684	33386248	.9443584	.8541240	3105590	322
104329	33698267	.9722008	.8612120	3095975	323
104976	34012224	18.0000000	.8682855	3086420	324
105625	34328125	18.0277564	6.8753443	.003076923	325
106276	34645976	.0554701	.8823888	3067485	326
106929	34965783	.0831413	.8894188	3058104	327
107584	35287552	.1107703	.8964345	3048780	328
108241	35611289	.1383571	.9034359	3039514	329
108900	35937000	18.1659021	6.9104232	.003030303	330
109561	36264691	.1934054	.9173964	3021148	331
110224	36594368	.2208672	.9243556	3012048	332
110889	36926037	.2482876	.9313008	3003003	333
111556	37259704	.2756669	.9382321	2994012	334
112225	37595375	18.3030052	6.9451496	.002985075	335
112896	37933056	.3303028	.9520533	2976190	336
113569	38272753	.3575598	.9589434	2967359	337
114244	38614472	.3847763	.9658198	2958580	338
114921	38958219	.4119526	.9726826	2949853	339
115600	39304000	18.4390889	6.9795321	.002941176	340
116281	39651821	.4661853	.9863681	2932551	341
116964	40001688	.4932420	.9931906	2923977	342
117649	40353607	.5202592	7.0000000	2915452	343
118336	40707584	.5472370	.0067962	2906977	344
119025	41063625	18.5741756	7.0135791	.002898551	345
119716	41421736	.6010752	.0203490	2890173	346
120409	41781923	.6279360	.0271058	2881844	347
121104	42144192	.6547581	.0338497	2873563	348
121801	42508549	.6815417	.0405806	2865330	349
122500	42875000	18.7082869	7.0472987	.002857143	350
123201	43243551	.7349940	.0540041	2849003	351
123904	43614208	.7616630	.0606967	2840909	352
124609	43986977	.7882942	.0673767	2832861	353
125316	44361864	.8148877	.0740440	2824859	354
126025	44738875	18.8414437	7.0806988	.002816901	355
126736	45118016	.8679623	.0873411	2808989	356
127449	45499293	.8944436	.0939709	2801120	357
128164	45882712	.9208879	.1005885	2793296	358
128881	46268279	.9472953	.1071937	2785515	359

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
360	129600	46656000	18.9736660	7.1137866	.002777778
361	130321	47045881	19.0000000	.1203674	2770083
362	131044	47437928	.0262976	.1269360	2762431
363	131769	47832147	.0525589	.1334925	2754821
364	132496	48228544	.0787840	.1400370	2747253
365	133225	48627125	19.1049732	7.1465695	.002739726
366	133956	49027896	.1311265	.1530901	2732240
367	134689	49430863	.1572441	.1595988	2724796
368	135424	49836032	.1833261	.1660957	2717391
369	136161	50243409	.2093727	.1725809	2710027
370	136900	50653000	19.2353841	7.1790544	.002702703
371	137641	51064811	.2613603	.1855162	2695418
372	138384	51478848	.2873015	.1919663	2688172
373	139129	51895117	.3132079	.1984050	2680965
374	139876	52313624	.3390796	.2048322	2673797
375	140625	52734375	19.3649167	7.2112479	.002666667
376	141376	53157376	.3907194	.2176522	2659574
377	142129	53582633	.4164878	.2240450	2652520
378	142884	54010152	.4422221	.2304268	2645503
379	143641	54439939	.4679223	.2367972	2638522
380	144400	54872000	19.4935887	7.2431565	.002631579
381	145161	55306341	.5192213	.2495045	2624672
382	145924	55742968	.5448203	.2558415	2617801
383	146689	56181887	.5703858	.2621675	2610966
384	147456	56623104	.5959179	.2684824	2604167
385	148225	57066625	19.6214169	7.2747864	.002597403
386	148996	57512456	.6468827	.2810794	2590674
387	149769	57960603	.6723156	.2873617	2583979
388	150544	58411072	.6977156	.2936330	2577320
389	151321	58863869	.7230829	.2998936	2570694
390	152100	59319000	19.7484177	7.3061436	.002564103
391	152881	59776471	.7737199	.3123828	2557545
392	153664	60236288	.7989899	.3186114	2551020
393	154449	60698457	.8242276	.3248295	2544529
394	155236	61162984	.8494332	.3310369	2538071
395	156025	61629875	19.8746069	7.3372339	.002531646
396	156816	62099136	.8997487	.3434205	2525253
397	157609	62570773	.9248588	.3495966	2518892
398	158404	63044792	.9499373	.3557624	2512563
399	159201	63521199	.9749844	.3619178	2506266
400	160000	64000000	20.0000000	7.3680630	.002500000
401	160801	64481201	.0249844	.3741979	2493766
402	161604	64964808	.0499377	.3803227	2487562
403	162409	65450827	.0748599	.3864373	2481390
404	163216	65939264	.0997512	.3925418	2475248
405	164025	66430125	20.1246118	7.3986363	.002469136
406	164836	66923416	.1494417	.4047206	2463054
407	165649	67419143	.1742410	.4107950	2457002
408	166464	67917312	.1990099	.4168595	2450980
409	167281	68417929	.2237484	.4229142	2444988
410	168100	68921000	20.2484567	7.4289589	.002439024
411	168921	69426531	.2731349	.4349938	2433090
412	169744	69934528	.2977831	.4410189	2427184
413	170569	70444997	.3224014	.4470342	2421308
414	171396	70957944	.3469899	.4530399	2415459
415	172225	71473375	20.3715488	7.4590359	.002409639
416	173056	71991296	.3960781	.4650223	2403846
417	173889	72511713	.4205779	.4709991	2398082
418	174724	73034632	.4450483	.4769664	2392345
419	175561	73560059	.4694895	.4829242	2386635

Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.	No.
176400	74088000	20.4939015	7.4888724	.002380952	420
177241	74618461	.5182845	.4948113	2375297	421
178084	75151448	.5426386	.5007406	2369668	422
178929	75686967	.5669638	.5066607	2364066	423
179776	76225024	.5912603	.5125715	2358491	424
180625	76765625	20.6155281	7.5184730	.002352941	425
181476	77308776	.6397674	.5243652	2347418	426
182329	77854483	.6639783	.5302482	2341920	427
183184	78402752	.6881609	.5361221	2336449	428
184041	78953589	.7123152	.5419867	2331002	429
184900	79507000	20.7364414	7.5478423	.002325581	430
185761	80062991	.7605395	.5536888	2320186	431
186624	80621568	.7846097	.5595263	2314815	432
187489	81182737	.8086520	.5653548	2309469	433
188356	81746504	.8326667	.5711743	2304147	434
189225	82312875	20.8566536	7.5769849	.002298851	435
190096	82881856	.8806130	.5827865	2293578	436
190969	83453453	.9045450	.5885793	2288330	437
191844	84027672	.9284495	.5943633	2283105	438
192721	84604519	.9523268	.6001385	2277904	439
193600	85184000	20.9761770	7.6059049	.002272727	440
194481	85766121	21.0000000	.6116626	2267574	441
195364	86350888	.0237960	.6174116	2262443	442
196249	86938307	.0475652	.6231519	2257336	443
197136	87528384	.0713075	.6288837	2252252	444
198025	88121125	21.0950231	7.6346067	.002247191	445
198916	88716536	.1187121	.6403213	2242152	446
199809	89314623	.1423745	.6460272	2237136	447
200704	89915392	.1660105	.6517247	2232143	448
201601	90518849	.1896201	.6574138	2227171	449
202500	91125000	21.2132034	7.6630943	.002222222	450
203401	91733851	.2367606	.6687665	2217295	451
204304	92345408	.2602916	.6744303	2212389	452
205209	92959677	.2837967	.6800857	2207506	453
206116	93576664	.3072758	.6857328	2202643	454
207025	94196375	21.3307290	7.6913717	.002197802	455
207936	94818816	.3541565	.6970023	2192982	456
208849	95443993	.3775583	.7026246	2188184	457
209764	96071912	.4009346	.7082388	2183406	458
210681	96702579	.4242853	.7138448	2178649	459
211600	97336000	21.4476106	7.7194426	.002173913	460
212521	97972181	.4709106	.7250325	2169197	461
213444	98611128	.4941853	.7306141	2164502	462
214369	99252847	.5174348	.7361877	2159827	463
215296	99897344	.5406592	.7417532	2155172	464
216225	100544625	21.5638587	7.7473109	.002150538	465
217156	101194696	.5870331	.7528606	2145923	466
218089	101847563	.6101828	.7584023	2141328	467
219024	102503232	.6333077	.7639361	2136752	468
219961	103161709	.6564078	.7694620	2132196	469
220900	103823000	21.6794834	7.7749801	.002127660	470
221841	104487111	.7025344	.7804904	2123142	471
222784	105154048	.7255610	.7859928	2118644	472
223729	105823817	.7485632	.7914875	2114165	473
224676	106496424	.7715411	.7969745	2109705	474
225625	107171875	21.7944947	7.8024538	.002105263	475
226576	107850176	.8174242	.8079254	2100840	476
227529	108531333	.8403297	.8133892	2096436	477
228484	109215352	.8632111	.8188456	2092050	478
229441	109902239	.8860686	.8242942	2087683	479

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
480	230400	110592000	21.9089023	7.8297353	.002083333
481	231361	111284641	.9317122	.8351688	2079002
482	232324	111980168	.9544984	.8405949	2074689
483	233289	112678587	.9772610	.8460134	2070393
484	234256	113379904	22.0000000	.8514244	2066116
485	235225	114084125	22.0227155	7.8568281	.002061856
486	236196	114791256	.0454077	.8622242	2057613
487	237169	115501303	.0680765	.8676130	2053388
488	238144	116214272	.0907220	.8729944	2049180
489	239121	116930169	.1133444	.8783684	2044990
490	240100	117649000	22.1359436	7.8837352	.002040816
491	241081	118370771	.1585198	.8890946	2036660
492	242064	119095488	.1810730	.8944468	2032520
493	243049	119823157	.2036033	.8997917	2028398
494	244036	120553784	.2261108	.9051294	2024291
495	245025	121287375	22.2485955	7.9104599	.002020202
496	246016	122023936	.2710575	.9157832	2016129
497	247009	122763473	.2934968	.9210994	2012072
498	248004	123505992	.3159136	.9264085	2008032
499	249001	124251499	.3383079	.9317104	2004008
500	250000	125000000	22.3606798	7.9370053	.002000000
501	251001	125751501	.3830293	.9422931	1996008
502	252004	126506008	.4053565	.9475739	1992032
503	253009	127263527	.4276615	.9528477	1988072
504	254016	128024064	.4499443	.9581144	1984127
505	255025	128787625	22.4722051	7.9633743	.001980198
506	256036	129554216	.4944438	.9686271	1976285
507	257049	130323843	.5166605	.9738731	1972387
508	258064	131096512	.5388553	.9791122	1968504
509	259081	131872229	.5610283	.9843444	1964637
510	260100	132651000	22.5831796	7.9895697	.001960784
511	261121	133432831	.6053091	.9947883	1956947
512	262144	134217728	.6274170	8.0000000	1953125
513	263169	135005697	.6495033	.0052049	1949318
514	264196	135796744	.6715681	.0104032	1945525
515	265225	136590875	22.6936114	8.0155946	.001941748
516	266256	137388096	.7156334	.0207794	1937984
517	267289	138188413	.7376340	.0259574	1934236
518	268324	138991832	.7596134	.0311287	1930502
519	269361	139798359	.7815715	.0362935	1926782
520	270400	140608000	22.8035085	8.0414515	.001923077
521	271441	141420761	.8254244	.0466030	1919386
522	272484	142236648	.8473193	.0517479	1915709
523	273529	143055667	.8691933	.0568862	1912046
524	274576	143877824	.8910463	.0620180	1908397
525	275625	144703125	22.9128785	8.0671432	.001904762
526	276676	145531576	.9346899	.0722620	1901141
527	277729	146363183	.9564806	.0773743	1897533
528	278784	147197952	.9782506	.0824800	1893939
529	279841	148035889	23.0000000	.0875794	1890359
530	280900	148877000	23.0217289	8.0926723	.001886792
531	281961	149721291	.0434372	.0977589	1883239
532	283024	150568768	.0651252	.1028390	1879699
533	284089	151419437	.0867928	.1079128	1876173
534	285156	152273304	.1084400	.1129803	1872659
535	286225	153130375	23.1300670	8.1180414	.001869159
536	287296	153990656	.1516738	.1230962	1865672
537	288369	154854153	.1732605	.1281447	1862197
538	289444	155720872	.1948270	.1331870	1858736
539	290521	156590819	.2163735	.1382230	1855288

Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.	No.
291600	157464000	23. 2379001	8. 1432529	.001851852	540
292681	158340421	.2594067	.1482765	1848429	541
293764	159220088	.2808935	.1532939	1845018	542
294849	160103007	.3023604	.1583051	1841621	543
295936	160989184	.3238076	.1633102	1838235	544
297025	161878625	23. 3452351	8. 1683092	.001834862	545
298116	162771336	.3666429	.1733020	1831502	546
299209	163667323	.3880311	.1782888	1828154	547
300304	164566592	.4093998	.1832695	1824818	548
301401	165469149	.4307490	.1882441	1821494	549
302500	166375000	23. 4520788	8. 1932127	.001818182	550
303601	167284151	.4733892	.1981753	1814882	551
304704	168196608	.4946802	.2031319	1811594	552
305809	169112377	.5159520	.2080825	1808318	553
306916	170031464	.5372046	.2130271	1805054	554
308025	170953875	23. 5584380	8. 2179657	.001801802	555
309136	171879616	.5796522	.2228985	1798561	556
310249	172808693	.6008474	.2278254	1795332	557
311364	173741112	.6220236	.2327463	1792115	558
312481	174676879	.6431808	.2376614	1788909	559
313600	175616000	23. 6643191	8. 2425706	.001785714	560
314721	176558481	.6854386	.2474740	1782531	561
315844	177504328	.7065392	.2523715	1779359	562
316969	178453547	.7276210	.2572633	1776199	563
318096	179406144	.7486842	.2621492	1773050	564
319225	180362125	23. 7697286	8. 2670294	.001769912	565
320356	181321496	.7907545	.2719039	1766784	566
321489	182284263	.8117618	.2767726	1763668	567
322624	183250432	.8327506	.2816355	1760563	568
323761	184220009	.8537209	.2864928	1757469	569
324900	185193000	23. 8746728	8. 2913444	.001754386	570
326041	186169411	.8956063	.2961903	1751313	571
327184	187149248	.9165215	.3010304	1748252	572
328329	188132517	.9374184	.3058651	1745201	573
329476	189119224	.9582971	.3106941	1742160	574
330625	190109375	23. 9791576	8. 3155175	.001739130	575
331776	191102976	24. 0000000	.3203353	1736111	576
332929	192100033	.0208243	.3251475	1733102	577
334084	193100552	.0416306	.3299542	1730104	578
335241	194104539	.0624188	.3347553	1727116	579
336400	195112000	24. 0831891	8. 3395509	.001724138	580
337561	196122941	.1039416	.3443410	1721170	581
338724	197137368	.1246762	.3491256	1718213	582
339889	198155287	.1453929	.3539047	1715266	583
341056	199176704	.1660919	.3586784	1712329	584
342225	200201625	24. 1867732	8. 3634466	.001709402	585
343396	201230056	.2074369	.3682095	1706485	586
344569	202262003	.2280829	.3729668	1703578	587
345744	203297472	.2487113	.3777188	1700680	588
346921	204336469	.2693222	.3824653	1697793	589
348100	205379000	24. 2899156	8. 3872065	.001694915	590
349281	206425071	.3104916	.3919423	1692047	591
350464	207474688	.3310501	.3966729	1689189	592
351649	208527857	.3515913	.4013981	1686341	593
352836	209584584	.3721152	.4061180	1683502	594
354025	210644875	24. 3926218	8. 4108326	.001680672	595
355216	211708736	.4131112	.4155419	1677852	596
356409	212776173	.4335834	.4202460	1675042	597
357604	213847192	.4540385	.4249448	1672241	598
358801	214921799	.4744765	.4296383	1669449	599

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.
600	360000	216000000	24.4948974	8.4343267	.001666667
601	361201	217081801	.5153013	.4390098	1663894
602	362404	218167208	.5356883	.4436877	1661130
603	363609	219256227	.5560583	.4483605	1658375
604	364816	220348864	.5764115	.4530281	1655629
605	366025	221445125	24.5967478	8.4576906	.001652893
606	367236	222545016	.6170673	.4623479	1650165
607	368449	223648543	.6373700	.4670001	1647446
608	369664	224755712	.6576560	.4716471	1644737
609	370881	225866529	.6779254	.4762892	1642036
610	372100	226981000	24.6981781	8.4809261	.001639344
611	373321	228099131	.7184142	.4855579	1636661
612	374544	229220928	.7386338	.4901848	1633987
613	375769	230346397	.7588368	.4948065	1631321
614	376996	231475544	.7790234	.4994233	1628664
615	378225	232608375	24.7991935	8.5040350	.001626016
616	379456	233744896	.8193473	.5086417	1623377
617	380689	234885113	.8394847	.5132435	1620746
618	381924	236029032	.8596058	.5178403	1618123
619	383161	237176659	.8797106	.5224321	1615509
620	384400	238328000	24.8997992	8.5270189	.001612903
621	385641	239483061	.9198716	.5316009	1610306
622	386884	240641848	.9399278	.5361780	1607717
623	388129	241804367	.9599679	.5407501	1605136
624	389376	242970624	.9799920	.5453173	1602564
625	390625	244140625	25.0000000	8.5498797	.001600000
626	391876	245314376	.0199920	.5544372	1597444
627	393129	246491883	.0399681	.5589899	1594896
628	394384	247673152	.0599282	.5635377	1592357
629	395641	248858189	.0798724	.5680807	1589825
630	396900	250047000	25.0998008	8.5726189	.001587302
631	398161	251239591	.1197134	.5771523	1584786
632	399424	252435968	.1396102	.5816809	1582278
633	400689	253636137	.1594913	.5862047	1579779
634	401956	254840104	.1793566	.5907238	1577287
635	403225	256047875	25.1992063	8.5952380	.001574803
636	404496	257259456	.2190404	.5997476	1572327
637	405769	258474853	.2388589	.6042525	1569859
638	407044	259694072	.2586619	.6087526	1567398
639	408321	260917119	.2784493	.6132480	1564945
640	409600	262144000	25.2982213	8.6177388	.001562500
641	410881	263374721	.3179778	.6222248	1560062
642	412164	264609288	.3377189	.6267063	1557632
643	413449	265847707	.3574447	.6311830	1555210
644	414736	267089984	.3771551	.6356551	1552795
645	416025	268336125	25.3968502	8.6401226	.001550388
646	417316	269586136	.4165301	.6445855	1547988
647	418609	270840023	.4361947	.6490437	1545595
648	419904	272097792	.4558441	.6534974	1543210
649	421201	273359449	.4754784	.6579465	1540832
650	422500	274625000	25.4950976	8.6623911	.001538462
651	423801	275894451	.5147016	.6668310	1536098
652	425104	277167808	.5342907	.6712665	1533742
653	426409	278445077	.5538647	.6756974	1531394
654	427716	279726264	.5734237	.6801237	1529052
655	429025	281011375	25.5929678	8.6845456	.001526718
656	430336	282300416	.6124969	.6889630	1524390
657	431649	283593393	.6320112	.6933759	1522070
	432964	284890312	.6515107	.6977843	1519757
	434281	286191179	.6709953	.7021882	1517451

Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.	No.
435600	287496000	25.6904652	8.7065877	.001515152	660
436921	288804781	.7099203	.7109827	1512859	661
438244	290117528	.7293607	.7153734	1510574	662
439569	291434247	.7487864	.7197596	1508296	663
440896	292754944	.7681975	.7241414	1506024	664
442225	294079625	25.7875939	8.7285187	.001503759	665
443556	295408296	.8069758	.7328918	1501502	666
444889	296740963	.8263431	.7372604	1499250	667
446224	298077632	.8456960	.7416246	1497006	668
447561	299418309	.8650343	.7459846	1494768	669
448900	300763000	25.8843582	8.7503401	.001492537	670
450241	302111711	.9036677	.7546913	1490313	671
451584	303464448	.9229628	.7590383	1488095	672
452929	304821217	.9422435	.7633809	1485884	673
454276	306182024	.9615100	.7677192	1483680	674
455625	307546875	25.9807621	8.7720532	.001481481	675
456976	308915776	26.0000000	.7763830	1479290	676
458329	310288733	.0192237	.7807084	1477105	677
459684	311665752	.0384331	.7850296	1474926	678
461041	313046839	.0576284	.7893466	1472754	679
462400	314432000	26.0768096	8.7936593	.001470588	680
463761	315821241	.0959767	.7979679	1468429	681
465124	317214568	.1151297	.8022721	1466276	682
466489	318611987	.1342687	.8065722	1464129	683
467856	320013504	.1533937	.8108681	1461988	684
469225	321419125	26.1725047	8.8151598	.001459854	685
470596	322828856	.1916017	.8194474	1457726	686
471969	324242703	.2106848	.8237307	1455604	687
473344	325660672	.2297541	.8280099	1453488	688
474721	327082769	.2488095	.8322850	1451379	689
476100	328509000	26.2678511	8.8365559	.001449275	690
477481	329939371	.2868789	.8408227	1447178	691
478864	331373888	.3058929	.8450854	1445087	692
480249	332812557	.3248932	.8493440	1443001	693
481636	334255384	.3438797	.8535985	1440922	694
483025	335702375	26.3628527	8.8578489	.001438849	695
484416	337153536	.3818119	.8620952	1436782	696
485809	338608873	.4007576	.8663375	1434720	697
487204	340068392	.4196896	.8705757	1432665	698
488601	341532099	.4386081	.8748099	1430615	699
490000	343000000	26.4575131	8.8790400	.001428571	700
491401	344472101	.4764046	.8832661	1426534	701
492804	345948408	.4952826	.8874882	1424501	702
494209	347428927	.5141472	.8917063	1422475	703
495616	348913664	.5329983	.8959204	1420455	704
497025	350402625	26.5518361	8.9001304	.001418440	705
498436	351895816	.5706605	.9043366	1416431	706
499849	353393243	.5894716	.9085387	1414427	707
501264	354894912	.6082694	.9127369	1412429	708
502681	356400829	.6270539	.9169311	1410437	709
504100	357911000	26.6458252	8.9211214	.001408451	710
505521	359425431	.6645833	.9253078	1406470	711
506944	360944128	.6833281	.9294902	1404494	712
508369	362467097	.7020598	.9336687	1402525	713
509796	363994344	.7207784	.9378433	1400560	714
511225	365525875	26.7394839	8.9420140	.001398601	715
512656	367061696	.7581763	.9461809	1396648	716
514089	368601813	.7768557	.9503438	1394700	717
515524	370146232	.7955220	.9545029	1392758	718
516961	371694959	.8141754	.9586581	1390821	719

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.	No.
720	518400	373248000	26.8328157	8.9628095	.001388889	720
721	519841	374805361	.8514432	.9669570	1386963	721
722	521284	376367048	.8700577	.9711007	1385042	722
723	522729	377933067	.8886593	.9752406	1383126	723
724	524176	379503424	.9072481	.9793766	1381215	724
725	525625	381078125	26.9258240	8.9835089	.001379310	725
726	527076	382657176	.9443872	.9876373	1377410	726
727	528529	384240583	.9629375	.9917620	1375516	727
728	529984	385828352	.9814751	.9958829	1373626	728
729	531441	387420489	27.0000000	9.0000000	1371742	729
730	532900	389017000	27.0185122	9.0041134	.001369863	730
731	534361	390617891	.0370117	.0082229	1367989	731
732	535824	392223168	.0554985	.0123288	1366120	732
733	537289	393832837	.0739727	.0164309	1364256	733
734	538756	395446904	.0924344	.0205293	1362398	734
735	540225	397065375	27.1108834	9.0246239	.001360544	735
736	541696	398688256	.1293199	.0287149	1358696	736
737	543169	400315553	.1477439	.0328021	1356852	737
738	544644	401947272	.1661554	.0368857	1355014	738
739	546121	403583419	.1845544	.0409655	1353180	739
740	547600	405224000	27.2029410	9.0450417	.001351351	740
741	549081	406869021	.2213152	.0491142	1349528	741
742	550564	408518488	.2396769	.0531831	1347709	742
743	552049	410172407	.2580263	.0572482	1345895	743
744	553536	411830784	.2763634	.0613098	1344086	744
745	555025	413493625	27.2946881	9.0653677	.001342282	745
746	556516	415160936	.3130006	.0694220	1340483	746
747	558009	416832723	.3313007	.0734726	1338688	747
748	559504	418508992	.3495887	.0775197	1336898	748
749	561001	420189749	.3678644	.0815631	1335113	749
750	562500	421875000	27.3861279	9.0856030	.001333333	750
751	564001	423564751	.4043792	.0896392	1331558	751
752	565504	425259008	.4226184	.0936719	1329787	752
753	567009	426957777	.4408455	.0977010	1328021	753
754	568516	428661064	.4590604	.1017265	1326260	754
755	570025	430368875	27.4772633	9.1057485	.001324503	755
756	571536	432081216	.4954542	.1097669	1322751	756
757	573049	433798093	.5136330	.1137818	1321004	757
758	574564	435519512	.5317998	.1177931	1319261	758
759	576081	437245479	.5499546	.1218010	1317523	759
760	577600	438976000	27.5680975	9.1258053	.001315789	760
761	579121	440711081	.5862284	.1298061	1314060	761
762	580644	442450728	.6043475	.1338034	1312336	762
763	582169	444194947	.6224546	.1377971	1310616	763
764	583696	445943744	.6405499	.1417874	1308901	764
765	585225	447697125	27.6586334	9.1457742	.001307190	765
766	586756	449455096	.6767050	.1497576	1305483	766
767	588289	451217663	.6947648	.1537375	1303781	767
768	589824	452984832	.7128129	.1577139	1302083	768
769	591361	454756609	.7308492	.1616869	1300390	769
770	592900	456533000	27.7488739	9.1656565	.001298701	770
771	594441	458314011	.7668868	.1696225	1297017	771
772	595984	460099648	.7848880	.1735852	1295337	772
773	597529	461889917	.8028775	.1775445	1293661	773
774	599076	463684824	.8208555	.1815003	1291990	774
775	600625	465484375	27.8388218	9.1854527	.001290323	775
776	602176	467288576	.8567766	.1894018	1288660	776
777	603729	469097433	.8747197	.1933474	1287001	777
778	605284	470910952	.8926514	.1972897	1285347	778
779	606841	472729139	.9105715	.2012286	1283697	779

Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.	No.
608400	474552000	27.9284801	9.2051641	.001282051	780
609961	476379541	.9463772	.2090962	1280410	781
611524	478211768	.9642629	.2130250	1278772	782
613089	480048687	.9821372	.2169505	1277139	783
614656	481890304	28.0000000	.2208726	1275510	784
616225	483736625	28.0178515	9.2247914	.001273885	785
617796	485587656	.0356915	.2287068	1272265	786
619369	487443403	.0535203	.2326189	1270648	787
620944	489303872	.0713377	.2365277	1269036	788
622521	491169069	.0891438	.2404333	1267427	789
624100	493039000	28.1069386	9.2443355	.001265823	790
625681	494913671	.1247222	.2482344	1264223	791
627264	496793088	.1424946	.2521300	1262626	792
628849	498677257	.1602557	.2560224	1261034	793
630436	500566184	.1780056	.2599114	1259446	794
632025	502459875	28.1957444	9.2637973	.001257862	795
633616	504358336	.2134720	.2676798	1256281	796
635209	506261573	.2311884	.2715592	1254705	797
636804	508169592	.2488938	.2754352	1253133	798
638401	510082399	.2665881	.2793081	1251564	799
640000	512000000	28.2842712	9.2831777	.001250000	800
641601	513922401	.3019434	.2870440	1248439	801
643204	515849608	.3196045	.2909072	1246883	802
644809	517781627	.3372546	.2947671	1245330	803
646416	519718464	.3548938	.2986239	1243781	804
648025	521660125	28.3725219	9.3024775	.001242236	805
649636	523606616	.3901391	.3063278	1240695	806
651249	525557943	.4077454	.3101750	1239157	807
652864	527514112	.4253408	.3140190	1237624	808
654481	529475129	.4429253	.3178599	1236094	809
656100	531441000	28.4604989	9.3216975	.001234568	810
657721	533411731	.4780617	.3255320	1233046	811
659344	535387328	.4956137	.3293634	1231527	812
660969	537367797	.5131549	.3331916	1230012	813
662596	539353144	.5306852	.3370167	1228501	814
664225	541343375	28.5482048	9.3408386	.001226994	815
665856	543338496	.5657137	.3446575	1225490	816
667489	545338513	.5832119	.3484731	1223990	817
669124	547343432	.6006993	.3522857	1222494	818
670761	549353259	.6181760	.3560952	1221001	819
672400	551368000	28.6356421	9.3599016	.001219512	820
674041	553387661	.6530976	.3637049	1218027	821
675684	555412248	.6705424	.3675051	1216545	822
677329	557441767	.6879766	.3713022	1215067	823
678976	559476224	.7054002	.3750963	1213592	824
680625	561515625	28.7228132	9.3788873	.001212121	825
682276	563559976	.7402157	.3826752	1210654	826
683929	565609283	.7576077	.3864600	1209190	827
685584	567663552	.7749891	.3902419	1207729	828
687241	569722789	.7923601	.3940206	1206273	829
688900	571787000	28.8097206	9.3977964	.001204819	830
690561	573856191	.8270706	.4015691	1203369	831
692224	575930368	.8444102	.4053387	1201923	832
693889	578009537	.8617394	.4091054	1200480	833
695556	580093704	.8790582	.4128690	1199041	834
697225	582182875	28.8963666	9.4166297	.001197605	835
698896	584277056	.9136646	.4203873	1196172	836
700569	586376253	.9309523	.4241420	1194743	837
702244	588480472	.9482297	.4278936	1193317	838
703921	590589719	.9654967	.4316423	1191895	839

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
840	705600	592704000	28.9827535	9.4353880	.00119047
841	707281	594823321	29.0000000	.4391307	118906
842	708964	596947688	.0172363	.4428704	118764
843	710649	599077107	.0344623	.4466072	118624
844	712336	601211584	.0516781	.4503410	118483
845	714025	603351125	29.0688837	9.4540719	.00118343
846	715716	605495736	.0860791	.4577999	118203
847	717409	607645423	.1032644	.4615249	118063
848	719104	609800192	.1204396	.4652470	117924
849	720801	611960049	.1376046	.4689661	117785
850	722500	614125000	29.1547595	9.4726824	.00117647
851	724201	616295051	.1719043	.4763957	117508
852	725904	618470208	.1890390	.4801061	117370
853	727609	620650477	.2061637	.4838136	117233
854	729316	622835864	.2232784	.4875182	117096
855	731025	625026375	29.2403830	9.4912200	.00116959
856	732736	627222016	.2574777	.4949188	116822
857	734449	629422793	.2745623	.4986147	116686
858	736164	631628712	.2916370	.5023078	116550
859	737881	633839779	.3087018	.5059980	116414
860	739600	636056000	29.3257566	9.5096854	.00116279
861	741321	638277381	.3428015	.5133699	116144
862	743044	640503928	.3598365	.5170515	116009
863	744769	642735647	.3768616	.5207303	115874
864	746496	644972544	.3938769	.5244063	115740
865	748225	647214625	29.4108823	9.5280794	.00115606
866	749956	649461896	.4278779	.5317497	115473
867	751689	651714363	.4448637	.5354172	115340
868	753424	653972032	.4618397	.5390818	115207
869	755161	656234909	.4788059	.5427437	115074
870	756900	658503000	29.4957624	9.5464027	.00114942
871	758641	660776311	.5127091	.5500589	114810
872	760384	663054848	.5296461	.5537123	114678
873	762129	665338617	.5465734	.5573630	114547
874	763876	667627624	.5634910	.5610108	114416
875	765625	669921875	29.5803989	9.5646559	.00114285
876	767376	672221376	.5972972	.5682982	114155
877	769129	674526133	.6141858	.5719377	114025
878	770884	676836152	.6310648	.5755745	113895
879	772641	679151439	.6479342	.5792085	113765
880	774400	681472000	29.6647939	9.5828397	.00113636
881	776161	683797841	.6816442	.5864682	113507
882	777924	686128968	.6984848	.5900939	113378
883	779689	688465387	.7153159	.5937169	113250
884	781456	690807104	.7321375	.5973373	113122
885	783225	693154125	29.7489496	9.6009548	.00112994
886	784996	695506456	.7657521	.6045696	112866
887	786769	697864103	.7825452	.6081817	112739
888	788544	700227072	.7993289	.6117911	112612
889	790321	702595369	.8161030	.6153977	112485
890	792100	704969000	29.8328678	9.6190017	.00112359
891	793881	707347971	.8496231	.6226030	112233
892	795664	709732288	.8663690	.6262016	112107
893	797449	712121957	.8831056	.6297975	111982
894	799236	714516984	.8998328	.6333907	111856
895	801025	716917375	29.9165506	9.6369812	.00111731
896	802816	719323136	.9332591	.6405690	111607
897	804609	721734273	.9499583	.6441542	111483
898	806404	724150792	.9666481	.6477367	111359
899	808201	726572699	.9833287	.6513166	111234

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Reciprocals.	No.
900	810000	729000000	30.0000000	9.6548938	.001111111	900
901	811801	731432701	.0166620	.6584684	1109878	901
902	813604	733870808	.0333148	.6620403	1108647	902
903	815409	736314327	.0499584	.6656096	1107420	903
904	817216	738763264	.0665928	.6691762	1106195	904
905	819025	741217625	30.0832179	9.6727403	.001104972	905
906	820836	743677416	.0998339	.6763017	1103753	906
907	822649	746142643	.1164407	.6798604	1102536	907
908	824464	748613312	.1330383	.6834166	1101322	908
909	826281	751089429	.1496269	.6869701	1100110	909
910	828100	753571000	30.1662063	9.6905211	.001098901	910
911	829921	756058031	.1827765	.6940694	1097695	911
912	831744	758550528	.1993377	.6976151	1096491	912
913	833569	761048497	.2158899	.7011583	1095290	913
914	835396	763551944	.2324329	.7046989	1094092	914
915	837225	766060875	30.2489669	9.7082369	.001092896	915
916	839056	768575296	.2654919	.7117723	1091703	916
917	840889	771095213	.2820079	.7153051	1090513	917
918	842724	773620632	.2985148	.7188354	1089325	918
919	844561	776151559	.3150128	.7223631	1088139	919
920	846400	778688000	30.3315018	9.7258883	.001086957	920
921	848241	781229061	.3479818	.7294109	1085776	921
922	850084	783777448	.3644529	.7329309	1084599	922
923	851929	786330467	.3809151	.7364484	1083424	923
924	853776	788889024	.3973683	.7399634	1082251	924
925	855625	791453125	30.4138127	9.7434758	.001081081	925
926	857476	794022776	.4302481	.7469857	1079914	926
927	859329	796597983	.4466747	.7504930	1078749	927
928	861184	799178752	.4630924	.7539979	1077586	928
929	863041	801765089	.4795013	.7575002	1076426	929
930	864900	804357000	30.4959014	9.7610001	.001075269	930
931	866761	806954491	.5122926	.7644974	1074114	931
932	868624	809557568	.5286750	.7679922	1072961	932
933	870489	812166237	.5450487	.7714845	1071811	933
934	872356	814780504	.5614136	.7749743	1070664	934
935	874225	817400375	30.5777697	9.7784616	.001069519	935
936	876096	820025856	.5941171	.7819466	1068376	936
937	877969	822656953	.6104557	.7854288	1067236	937
938	879844	825293672	.6267857	.7889087	1066098	938
939	881721	827936019	.6431069	.7923861	1064963	939
940	883600	830584000	30.6594194	9.7958611	.001063830	940
941	885481	833237621	.6757233	.7993336	1062699	941
942	887364	835896888	.6920185	.8028036	1061571	942
943	889249	838561807	.7083051	.8062711	1060445	943
944	891136	841232384	.7245830	.8097362	1059322	944
945	893025	843908625	30.7408523	9.8131989	.001058201	945
946	894916	846590536	.7571130	.8166591	1057082	946
947	896809	849278123	.7733651	.8201169	1055966	947
948	898704	851971392	.7896086	.8235723	1054852	948
949	900601	854670349	.8058436	.8270252	1053741	949
950	902500	857375000	30.8220700	9.8304757	.001052632	950
951	904401	860085351	.8382879	.8339238	1051525	951
952	906304	862801408	.8544972	.8373695	1050420	952
953	908209	865523177	.8706981	.8408127	1049318	953
954	910116	868250664	.8868904	.8442536	1048218	954
955	912025	870983875	30.9030743	9.8476920	.001047120	955
956	913936	873722816	.9192497	.8511280	1046025	956
957	915849	876467493	.9354166	.8545617	1044932	957
958	917764	879217912	.9515751	.8579929	1043841	958
959	919681	881974079	.9677251	.8614218	1042753	959

No.	Squares.	Cubes.	Square Roots.	Cube Roots.	Recipro-cals.
960	921600	884736000	30.9838668	9.8648483	.001041667
961	923521	887503681	31.0000000	.8682724	1040583
962	925444	890277128	.0161248	.8716941	1039501
963	927369	893056347	.0322413	.8751135	1038422
964	929296	895841344	.0483494	.8785305	1037344
965	931225	898632125	31.0644491	9.8819451	.001036269
966	933156	901428696	.0805405	.8853574	1035192
967	935089	904231063	.0966236	.8887673	1034120
968	937024	907039232	.1126984	.8921749	1033050
969	938961	909853209	.1287648	.8955801	1031992
970	940900	912673000	31.1448230	9.8989830	.001030928
971	942841	915498611	.1608729	.9023835	1029866
972	944784	918330048	.1769145	.9057817	1028807
973	946729	921167317	.1929479	.9091776	1027749
974	948676	924010424	.2089731	.9125712	1026694
975	950625	926859375	31.2249900	9.9159624	.001025641
976	952576	929714176	.2409987	.9193513	1024590
977	954529	932574833	.2569992	.9227379	1023541
978	956484	935441352	.2729915	.9261222	1022495
979	958441	938313739	.2889757	.9295042	1021450
980	960400	941192000	31.3049517	9.9328839	.001020408
981	962361	944076141	.3209195	.9362613	1019368
982	964324	946966168	.3368792	.9396363	1018330
983	966289	949862087	.3528308	.9430092	1017294
984	968256	952763904	.3687743	.9463797	1016260
985	970225	955671625	31.3847097	9.9497479	.001015228
986	972196	958585256	.4006369	.9531138	1014199
987	974169	961504803	.4165561	.9564775	1013171
988	976144	964430272	.4324673	.9598389	1012146
989	978121	967361669	.4483704	.9631981	1011122
990	980100	970299000	31.4642654	9.9665549	.001010101
991	982081	973242271	.4801525	.9699095	1009082
992	984064	976191488	.4960315	.9732619	1008065
993	986049	979146657	.5119025	.9766120	1007049
994	988036	982107784	.5277655	.9799599	1006036
995	990025	985074875	31.5436206	9.9833055	.001005025
996	992016	988047936	.5594677	.9866488	1004015
997	994009	991026973	.5753068	.9899900	1003009
998	996004	994011992	.5911380	.9933289	1002004
999	998001	997002999	.6069613	.9966656	1001001
1000	1000000	1000000000	31.6227766	10.0000000	.001000000
1001	1002001	1003003001	.6385840	.0033322	0999001
1002	1004004	1006012008	.6543836	.0066622	0998004
1003	1006009	1009027027	.6701752	.0099899	0997009
1004	1008016	1012048064	.6859590	.0133155	0996016
1005	1010025	1015075125	31.7017349	10.0166389	.000995025
1006	1012036	1018108216	.7175030	.0199601	0994036
1007	1014049	1021147343	.7332633	.0232791	0993049
1008	1016064	1024192512	.7490157	.0265958	0992063
1009	1018081	1027243729	.7647603	.0299104	0991080
1010	1020100	1030301000	31.7804972	10.0332228	.000990099
1011	1022121	1033364331	.7962262	.0365330	0989120
1012	1024144	1036433728	.8119474	.0398410	0988142
1013	1026169	1039509197	.8276609	.0431469	0987167
1014	1028196	1042590744	.8433666	.0464506	0986193
1015	1030225	1045678375	31.8590646	10.0497521	.000985222
1016	1032256	1048772096	.8747549	.0530514	0984253
1017	1034289	1051871913	.8904374	.0563485	0983
1018	1036324	1054977832	.9061123	.0596435	0982
1019	1038361	1058089859	.9217794	.0629364	098

Gauge 4′ 8½″=4.7083.

g	Frog Angle	Rad. of Turnout	Deg. of Turnout	Lead E.	Crotch No.	Crotch Angle	Crotch Lead	Frog No.
	14°15′	150.67	38°46′	37.67	2.82	20°08′	26.84	4
½	12 41	190.69	30 24	42.37	3.17	17 55	30.15	4½
	11 25	235.42	24 31	47.08	3.53	16 08	33.46	5
½	10 23	284.85	20 13	51.79	3.88	14 41	36.77	5½
	9 32	339.00	16 58	56.50	4.24	13 28	40.09	6
½	8 48	397.85	14 26	61.21	4.59	12 26	43.41	6½
	8 10	461.42	12 27	65.92	4.94	11 33	46.73	7
½	7 38	529.69	10 50	70.62	5.30	10 47	50.05	7½
	7 09	602.67	9 31	75.33	5.65	10 07	53.37	8
½	6 44	680.35	8 26	80.04	6.01	9 31	56.70	8½
	6 22	762.75	7 31	84.75	6.36	8 59	60.02	9
½	6 02	849.85	6 45	89.46	6.71	8 31	63.34	9½
	5 43	941.67	6 05	94.17	7.07	8 06	66.67	10
½	5 27	1038.19	5 31	98.88	7.42	7 43	69.99	10½
	5 12	1139.42	5 02	103.58	7.77	7 22	73.32	11
½	4 59	1245.35	4 36	108.29	8.13	7 02	76.65	11½
	4 46	1356.00	4 14	113.00	8.48	6 45	79.97	12

Gauge 3′

g	Frog Angle	Rad. of Turnout	Deg. of Turnout	Lead E.	Crotch No.	Crotch Angle	Crotch Lead	Frog No.
	14°15′	96.0	62°47′	24.	2.82	20°08′	17.10	4
½	12 41	121.5	48 36	27.	3.17	17 55	19.21	4½
	11 25	150.0	38 57	30.	3.53	16 08	21.32	5
½	10 23	181.5	31 59	33.	3.88	14 41	23.43	5½
	9 32	216.0	26 46	36.	4.24	13 28	25.54	6
½	8 48	253.5	22 45	39.	4.59	12 26	27.66	6½
	8 10	294.0	19 35	42.	4.94	11 33	29.77	7
½	7 38	337.5	17 02	45.	5.30	10 47	31.89	7½
	7 09	384.0	14 58	48.	5.65	10 07	34.01	8
½	6 44	433.5	13 15	51.	6.01	9 31	36.12	8½
	6 22	486.0	11 49	54.	6.36	8 59	38.24	9
½	6 02	541.5	10 36	57.	6.71	8 31	40.36	9½
	5 43	600.0	9 34	60.	7.07	8 06	42.48	10
½	5 27	661.5	8 40	63.	7.42	7 43	44.60	10½
	5 12	726.0	7 54	66.	7.77	7 22	46.72	11
½	4 59	793.5	7 14	69.	8.13	7 02	48.84	11½
	4 46	864.0	6 38	72.	8.48	6 45	50.96	12

Gauge 4′ 9″=4.75

g	Frog Angle	Rad. of Turnout	Deg. of Turnout	Lead E.	Crotch No.	Crotch Angle	Crotch Lead	Frog No.
	14°15′	152.00	38°25′	38.00	2.82	20°08′	27.08	4
½	12 41	192.38	30 08	42.75	3.17	17 55	30.41	4½
	11 25	237.50	24 18	47.50	3.53	16 08	33.76	5
½	10 23	287.38	20 02	52.25	3.88	14 41	37.10	5½
	9 32	342.00	16 49	57.00	4.24	13 28	40.44	6
½	8 48	401.38	14 19	61.75	4.59	12 26	43.79	6½
	8 10	465.50	12 20	66.50	4.94	11 33	47.14	7
½	7 38	534.38	10 44	71.25	5.30	10 47	50.49	7½
	7 09	608.00	9 26	76.00	5.65	10 07	53.84	8
½	6 44	686.38	8 21	80.75	6.01	9 31	57.20	8½
	6 22	769.50	7 27	85.50	6.36	8 59	60.55	9
½	6 02	857.38	6 41	90.25	6.71	8 31	63.90	9½
	5 43	950.00	6 02	95.00	7.07	8 06	67.26	10
½	5 27	1047.38	5 28	99.75	7.42	7 43	70.61	10½
	5 12	1149.50	4 59	104.50	7.77	7 22	73.97	11
½	4 59	1256.38	4 34	109.25	8.13	7 02	77.32	11½
	4 46	1368.00	4 11	114.00	8.48	6 45	80.68	12

TABLE XXII. A.—A. R. E. A. SPLIT SWITCH TURNOUTS

Number of Frog	Properties of Frogs Thickness of Point = 1"				Switches Th. of Point = 1" Spread of Heel = 6½"		Theoretical Leads			
	Angle of Frog	Theoretical Point to Toe	Theoretical Point to Heel	Spread at Toe	Spread at Heel	Actual Length of Rail	Switch Angle	Radius of Turnout Curve	Degree of Turnout Curve	Point of Switch to Theoretical Point of Frog	Closure Straight Rail	Closure Curved Rail
4	14°15′00″	3′ 2″	5′ 4″	.79′	1.32′	11′0″	2°36′19″	112.26	52°53′30″	37.05′	22.88′	23.29′
	11 25 16	3 7	6 5	.71	1.28	11 0	2 36 19	183.22	31 40 24	42.77	28.19	28.55
5	9 31 38	4 0	7 0	.66	1.16	11 0	2 36 19	273.95	21 01 58	48.11	33.11	33.38
6	8 10 16	4 5	8 1	.63	1.15	16 6	1 44 11	364.88	15 47 19	61.94	41.02	41.24
7	7 09 10	4 9	8 9	.59	1.09	16 6	1 44 11	488.71	11 44 40	67.47	46.22	46.42
8	6 21 35	6 0	10 0	.67	1.11	16 6	1 44 11	616.27	9 18 27	72.24	49.74	49.92
9	6 01 32	6 0	10 0	.63	1.05	16 6	1 44 11	699.97	8 11 33	74.90	52.40	52.58
9½	5 43 29	6 0	10 6	.60	1.05	16 6	1 44 11	790.25	7 15 18	77.31	55.01	55.17
10	5 12 18	6 0	11 6	.54	1.05	22 0	1 18 08	940.21	6 05 48	92.06	64.06	64.20
11	4 46 19	6 5	12 1	.53	1.01	22 0	1 18 08	1136.34	5 02 38	97.35	68.83	68.96
12	3 49 06	7 8	14 10	.51	.99	33 0	0 52 05	1744.45	3 17 06	130.50	89.83	89.94
13	3 34 47	8 0	16 0	.50	1.00	33 0	0 52 05	2005.98	2 51 24	135.95	94.95	95.05
15	3 10 56	8 10	17 8	.49	.98	33 0	0 52 05	2587.66	2 12 52	146.38	104.54	104.61
16	2 51 51	9 8	19 4	.48	.97	33 0	0 52 05	3262.98	1 45 22	156.35	113.68	113.76
18	2 33 13	11 4	23 2	.47	.97	33 0	0 52 05	4032.77	1 09 42	175.09	130.66	130.77
20												

TABLE XXII. B.—A. R. E. A. SPLIT SWITCH TURNOUTS

Number of Frog	Radius of Turnout Curve	Degree of Turnout Curve	Tangents		Point of Switch to Theoretical Point of Frog	Point of Switch to Actual Point of Frog	Closure of Straight Rail	Closure of Curved Rail	Coördinates of Curved Rail referred to Straight Rail with Origin at Point of Switch					
			Next to Switch Rail	Next to Frog										
4	110.69′	53°42′24″	1.03′	0.00′	37.77′	37.94′	23.60′	24′	17.74′	0.97′	23.44′	1.67′	29.75′	2.79′
5	174.34	33 19 57	0.00	0.82	42.26	42.47	27.68	28	17.78	0.95	24.54	1.61	31.27	2.62
6	265.39	21 43 04	0.00	0.66	47.73	47.98	32.73	33	19.07	1.01	27.13	1.74	35.15	2.72
7	362.08	15 52 29	0.00	0.19	61.81	62.10	13.89 + 27	14.11 + 27	26.72	0.97	36.93	1.71	47.11	2.74
8	487.48	11 46 27	0.30	0.00	67.65	67.98	16.40 + 30	16.60 + 30	28.37	1.02	39.91	1.78	51.45	2.91
9	605.18	9 28 42	0.00	0.57	71.91	72.28	16.41 + 33	16.59 + 33	28.75	1.02	40.98	1.76	53.19	2.75
9½	695.45	8 14 45	0.76	0.00	75.32	75.71	25.82 + 27	26.00 + 27	30.31	1.06	43.35	1.82	56.37	2.83
10	790.25	7 15 18	0.00	0.00	77.51	77.93	27.00 + 28	27.17 + 28	30.28	1.06	44.05	1.84	57.81	2.85
11	922.65	6 12 47	2.99	0.00	93.85	94.31	32.85 + 33	2 × 33	40.74	1.08	56.47	1.84	72.19	2.87
12	1098.73	5 12 59	5.33	0.00	100.30	100.80	23.88 + 2 × 24	3 × 24	43.99	1.15	60.65	1.90	77.28	2.91
15	1743.80	3 17 10	0.09	0.00	130.56	131.19	29.89 + 2 × 30	3 × 30	55.49	1.01	77.98	1.78	100.45	2.84
16	1993.24	2 52 59	1.56	0.00	136.90	137.57	29.90 + 2 × 33	30.00 + 2 × 33	58.16	1.04	81.76	1.82	105.35	2.87
18	2546.31	2 14 31	0.00	1.08	145.76	146.51	25.93 + 3 × 26	4 × 26	58.73	1.04	84.46	1.82	110.10	2.86
20	3257.26	1 45 32	0.44	0.00	156.59	157.42	26.92 + 2 × 27 + 33	33.00 + 3 × 27	61.84	1.08	90.21	1.88	118.59	2.93
24	4886.16	1 10 21	2.43	0.00	176.22	177.22	32.89 + 3 × 33	4 × 33	67.82	1.27	100.21	1.97	132.59	3.00

7	1.74	1.79	1.84	1.89	1.94	2.00	2.05	2.10	2.16
8	2.27	2.33	2.39	2.45	2.50	2.56	2.63	2.69	2.75
9	2.88	2.94	3.00	3.07	3.14	3.20	3.27	3.34	3.41
10	3.55	3.62	3.69	3.77	3.84	3.91	3.99	4.06	4.14
11	4.30	4.37	4.45	4.53	4.61	4.69	4.78	4.86	4.94
12	5.11	5.20	5.28	5.37	5.46	5.55	5.64	5.73	5.82
13	6.00	6.09	6.19	6.28	6.37	6.47	6.57	6.66	6.76
14	6.96	7.06	7.16	7.26	7.36	7.46	7.57	7.67	7.78
15	7.99	8.09	8.20	8.31	8.42	8.53	8.64	8.75	8.86
16	9.09	9.20	9.32	9.43	9.55	9.66	9.78	9.89	10.02
17	10.26	10.38	10.50	10.62	10.75	10.87	11.00	11.12	11.25
18	11.50	11.63	11.76	11.89	12.02	12.15	12.28	12.41	12.55
19	12.82	12.95	13.09	13.22	13.36	13.50	13.64	13.78	13.92
20	14.20	14.34	14.49	14.63	14.77	14.92	15.06	15.21	15.36
21	15.66	15.80	15.96	16.11	16.26	16.41	16.56	16.72	16.87
22	17.18	17.34	17.50	17.65	17.81	17.97	18.13	18.29	18.45
23	18.78	18.94	19.11	19.27	19.44	19.60	19.77	19.94	20.11
24	20.45	20.62	20.79	20.96	21.14	21.31	21.48	21.66	21.83
25	22.19	22.37	22.54	22.72	22.90	23.08	23.27	23.45	23.63
26	24.00	24.18	24.37	24.55	24.74	24.93	25.12	25.31	25.50
27	25.88	26.07	26.26	26.46	26.65	26.85	27.04	27.24	27.44
28	27.83	28.03	28.23	28.43	28.63	28.83	29.04	29.24	29.45
29	29.86	30.06	30.27	30.48	30.68	30.89	31.10	31.31	31.53
30	31.95	32.16	32.38	32.59	32.81	33.02	33.24	33.46	33.68
31	34.12	34.34	34.56	34.78	35.00	35.22	35.45	35.67	35.90
32	36.35	36.58	36.81	37.04	37.27	37.50	37.73	37.96	38.19
33	38.66	38.89	39.13	39.37	39.60	39.84	40.08	40.32	40.56
34	41.04	41.28	41.52	41.77	42.01	42.25	42.50	42.75	42.99
35	43.49	43.74	43.99	44.24	44.49	44.74	44.99	45.24	45.50
36	46.01	46.26	46.52	46.78	47.04	47.29	47.55	47.81	48.08
37	48.60	48.86	49.13	49.39	49.66	49.92	50.19	50.46	50.72
38	51.26	51.53	51.80	52.07	52.35	52.62	52.89	53.17	53.44
39	54.00	54.27	54.55	54.83	55.11	55.39	55.67	55.95	56.23
40	56.80	57.08	57.37	57.66	57.94	58.23	58.52	58.81	59.09
41	59.68	59.97	60.26	60.55	60.85	61.14	61.43	61.73	62.03
42	62.62	62.92	63.22	63.52	63.82	64.12	64.42	64.73	65.03
43	65.64	65.95	66.25	66.56	66.87	67.17	67.48	67.79	68.10

TABLE XXIII. — VELOCITY HEIGHTS.

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
50	88.75	89.11	89.46	89.82	90.18	90.53	90.89	91.25	91.61	91.97
51	92.34	92.70	93.06	93.42	93.79	94.15	94.52	94.89	95.26	95.62
52	95.99	96.36	96.73	97.10	97.47	97.85	98.22	98.59	98.97	99.34
53	99.72	100.10	100.47	100.85	101.23	101.61	101.99	102.37	102.75	103.13
54	103.52	103.90	104.29	104.67	105.06	105.44	105.83	106.22	106.61	107.00
55	107.39	107.78	108.17	108.56	108.96	109.35	109.74	110.14	110.53	110.93
56	111.33	111.73	112.12	112.52	112.92	113.32	113.73	114.13	114.53	114.94
57	115.34	115.74	116.15	116.56	116.96	117.37	117.78	118.19	118.60	119.01
58	119.42	119.83	120.25	120.66	121.07	121.49	121.91	122.32	122.74	123.16
59	123.58	123.99	124.41	124.84	125.26	125.68	126.10	126.53	126.95	127.37
60	127.80	128.23	128.65	129.08	129.51	129.94	130.37	130.80	131.23	131.66
61	132.10	132.53	132.96	133.40	133.83	134.27	134.71	135.14	135.58	136.02
62	136.46	136.90	137.34	137.79	138.23	138.67	139.12	139.56	140.01	140.45
63	140.90	141.35	141.80	142.24	142.69	143.14	143.60	144.05	144.50	144.95
64	145.41	145.86	146.32	146.77	147.23	147.69	148.15	148.61	149.07	149.53
65	149.99	150.45	150.91	151.38	151.84	152.30	152.77	153.24	153.70	154.17
66	154.64	155.11	155.58	156.05	156.52	156.99	157.46	157.94	158.41	158.88
67	159.36	159.84	160.31	160.79	161.27	161.75	162.23	162.71	163.29	163.67
68	164.15	164.64	165.12	165.60	166.09	166.57	167.06	167.55	168.04	168.53
69	169.02	169.51	170.00	170.49	170.98	171.47	171.97	172.46	172.96	173.45
70	173.95	174.45	174.95	175.44	175.94	176.44	176.94	177.45	177.95	178.45
71	178.96	179.46	179.97	180.47	180.98	181.48	181.99	182.50	183.01	183.52
72	184.03	184.54	185.06	185.57	186.08	186.60	187.11	187.63	188.14	188.66
73	189.18	189.70	190.22	190.74	191.26	191.78	192.30	192.82	193.35	193.87
74	194.40	194.92	195.45	195.98	196.51	197.03	197.56	198.09	198.62	199.16
75	199.69	200.22	200.75	201.29	201.82	202.36	202.90	203.43	203.97	204.51
76	205.05	205.59	206.13	206.67	207.21	207.75	208.30	208.84	209.39	209.93
77	210.48	211.03	211.57	212.12	212.67	213.22	213.77	214.32	214.88	215.43
78	215.98	216.54	217.09	217.65	218.20	218.76	219.32	219.88	220.44	220.99
79	221.56	222.12	222.68	223.24	223.80	224.37	224.93	225.50	226.07	226.63
80	227.20	227.77	228.34	228.91	229.48	230.05	230.62	231.19	231.77	232.34
81	232.92	233.49	234.07	234.64	235.22	235.80	236.38	236.96	237.54	238.12
82	238.70	239.28	239.87	240.45	241.04	241.62	242.21	242.79	243.38	243.97
83	244.56	245.15	245.74	246.33	246.92	247.51	248.11	248.70	249.30	249.89
84	250.49	251.08	251.68	252.28	252.88	253.48	254.08	254.68	255.28	255.88
85	256.49	257.09	257.70	258.30	258.91	259.51	260.12	260.73	261.34	261.95
86	262.56	263.17	263.78	264.39	265.01	265.62	266.23	266.85	267.47	268.08
87	268.70	269.32	269.94	270.56	271.18	271.80	272.42	273.04	273.66	274.29
88	274.91	275.54	276.16	276.79	277.42	278.04	278.67	279.30	279.93	280.56
89	281.20	281.83	282.46	283.09	283.73	284.36	285.00	285.64	286.27	286.91
90	287.55	288.19	288.83	289.47	290.11	290.75	291.40	292.04	292.68	293.33
91	293.98	294.62	295.27	295.92	296.57	297.21	297.86	298.52	299.17	299.82
92	300.47	301.13	301.78	302.43	303.09	303.75	304.40	305.06	305.72	306.38
93	307.04	307.70	308.36	309.02	309.69	310.35	311.01	311.68	312.34	313.01
94	313.68	314.35	315.01	315.68	316.35	317.02	317.70	318.37	319.04	319.71
95	320.39	321.06	321.74	322.41	323.09	323.77	324.45	325.13	325.81	326.49
96	327.17	327.85	328.53	329.22	329.90	330.58	331.27	331.96	332.64	333.33
97	334.02	334.71	335.40	336.09	336.78	337.47	338.16	338.86	339.55	340.25
98	340.94	341.64	342.34	343.03	343.73	344.43	345.13	345.83	346.53	347.23
99	347.94	348.64	349.34	350.05	350.75	351.46	352.17	352.87	353.58	354.29
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9

TABLE XXIV.—RISE PER MILE OF VARIOUS GRADES

Grade per Station	Rise per Mile	Grade per Station	Rise per Mile	Grade per Station	Rise per Mile	Grade per Station	Rise per Mile
.01	.528	.61	32.208	1.21	63.888	1.81	95.568
.02	1.056	.62	32.736	1.22	64.416	1.82	96.096
.03	1.584	.63	33.264	1.23	64.944	1.83	96.624
.04	2.112	.64	33.792	1.24	65.472	1.84	97.152
.05	2.640	.65	34.320	1.25	66.000	1.85	97.680
.06	3.168	.66	34.848	1.26	66.528	1.86	98.208
.07	3.696	.67	35.376	1.27	67.056	1.87	98.736
.08	4.224	.68	35.904	1.28	67.584	1.88	99.264
.09	4.752	.69	36.432	1.29	68.112	1.89	99.792
.10	5.280	.70	36.960	1.30	68.640	1.90	100.320
.11	5.808	.71	37.488	1.31	69.168	1.91	100.848
.12	6.336	.72	38.016	1.32	69.696	1.92	101.376
.13	6.864	.73	38.544	1.33	70.224	1.93	101.904
.14	7.392	.74	39.072	1.34	70.752	1.94	102.432
.15	7.920	.75	39.600	1.35	71.280	1.95	102.960
.16	8.448	.76	40.128	1.36	71.808	1.96	103.488
.17	8.976	.77	40.656	1.37	72.336	1.97	104.016
.18	9.504	.78	41.184	1.38	72.864	1.98	104.544
.19	10.032	.79	41.712	1.39	73.392	1.99	105.072
.20	10.560	.80	42.240	1.40	73.920	2.00	105.600
.21	11.088	.81	42.768	1.41	74.448	2.10	110.880
.22	11.616	.82	43.296	1.42	74.976	2.20	116.160
.23	12.144	.83	43.824	1.43	75.504	2.30	121.440
.24	12.672	.84	44.352	1.44	76.032	2.40	126.720
.25	13.200	.85	44.880	1.45	76.560	2.50	132.000
.26	13.728	.86	45.408	1.46	77.088	2.60	137.280
.27	14.256	.87	45.936	1.47	77.616	2.70	142.560
.28	14.784	.88	46.464	1.48	78.144	2.80	147.840
.29	15.312	.89	46.992	1.49	78.672	2.90	153.120
.30	15.840	.90	47.520	1.50	79.200	3.00	158.400
.31	16.368	.91	48.048	1.51	79.728	3.10	163.680
.32	16.896	.92	48.576	1.52	80.256	3.20	168.960
.33	17.424	.93	49.104	1.53	80.784	3.30	174.240
.34	17.952	.94	49.632	1.54	81.312	3.40	179.520
.35	18.480	.95	50.160	1.55	81.840	3.50	184.800
.36	19.008	.96	50.688	1.56	82.368	3.60	190.080
.37	19.536	.97	51.216	1.57	82.896	3.70	195.360
.38	20.064	.98	51.744	1.58	83.424	3.80	200.640
.39	20.592	.99	52.272	1.59	83.952	3.90	205.920
.40	21.120	1.00	52.800	1.60	84.480	4.00	211.200
.41	21.648	1.01	53.328	1.61	85.008	4.10	216.480
.42	22.176	1.02	53.856	1.62	85.536	4.20	221.760
.43	22.704	1.03	54.384	1.63	86.064	4.30	227.040
.44	23.232	1.04	54.912	1.64	86.592	4.40	232.320
.45	23.760	1.05	55.440	1.65	87.120	4.50	237.600
.46	24.288	1.06	55.968	1.66	87.648	4.60	242.880
.47	24.816	1.07	56.496	1.67	88.176	4.70	248.160
.48	25.344	1.08	57.024	1.68	88.704	4.80	253.440
.49	25.872	1.09	57.552	1.69	89.232	4.90	258.720
.50	26.400	1.10	58.080	1.70	89.760	5.00	264.000
.51	26.928	1.11	58.608	1.71	90.288	5.10	269.280
.52	27.456	1.12	59.136	1.72	90.816	5.20	274.560
.53	27.984	1.13	59.664	1.73	91.344	5.30	279.840
.54	28.512	1.14	60.192	1.74	91.872	5.40	285.120
.55	29.040	1.15	60.720	1.75	92.400	5.50	290.400
.56	29.568	1.16	61.248	1.76	92.928	5.60	295.680
.57	30.096	1.17	61.776	1.77	93.456	5.70	300.960
.58	30.624	1.18	62.304	1.78	93.984	5.80	306.240
.59	31.152	1.19	62.832	1.79	94.512	5.90	311.520
.60	31.680	1.20	63.360	1.80	95.040	6.00	316.800

TABLE XXV.—ELEVATION OF OUTER RAIL ON CURVES.

Degree of Curve	Velocity in Miles per Hour											
	10	15	20	25	30	35	40	45	50	55	60	65
0°30′	1/16″	1/16″	1/8″	5/16″	1/16″	3/8″	1/2″	11/16″	13/16″	1″	1 5/16″	1 3/4″
	1/16	1/8	1/4	7/16	5/16	13/16	1 1/16	1 5/16	1 5/8	2	2 3/8	2 13/16
30	1/8	1/4	3/8	1/2	7/16	1 3/16	1 5/16	2	2 1/16	3	3 5/16	4 3/16
	1/8	5/16	1/2	11/16	1 5/16	1 1/2	2 1/16	2 1/16	3 5/16	4	4 3/4	5 5/16
30	5/16	3/8	11/16	1	1 1/2	2	2 3/8	3 5/16	4 1/16	5	5 11/16	6 11/16
	5/16	7/16	11/16	1 1/4	1 3/4	2 5/16	3 5/16	4	4 11/16	6	7 1/8	8 3/8
30	3/8	1/2	11/16	1 5/16	2 1/16	2 11/16	3 1/16	4 1/16	5 1/4	7	8 5/16	
	3/8	5/16	1 1/16	1 1/2	2 3/8	3 1/4	4 1/4	5 1/16	6 1/2	8	9 1/2	
30	5/16	1/2	1 5/16	1 7/8	2 11/16	3 3/8	4 3/8	6	7 5/16	9		
	5/16	3/8	1 5/16	2 1/16	2 11/16	4 1/16	5 1/4	6 1/16	8 1/4	10		
30	3/8	1/16	1 7/16	2 1/4	3 1/4	4 1/16	5 1/16	7 1/8	9 1/16			
	3/8	7/16	1 5/16	2 1/2	3 5/16	4 3/8	6 5/16	8	9 3/8			
30	7/16	1/2	1 11/16	2 11/16	3 7/16	5 1/4	6 3/8	8 1/16				
	7/16	1 1/16	1 7/8	2 3/8	4 1/4	5 3/8	7 3/8	9 3/8				
30	1/2	1 1/8	2	3 1/16	4 7/16	6 1/16	7 11/16					
	1/2	1 1/16	2 1/8	3 5/16	4 3/4	6 7/16	8 1/16					
30	5/16	1 1/4	2 1/4	3 1/2	5 1/16	6 3/8	9					
	5/16	1 5/16	2 3/8	3 11/16	5 5/16	7 1/4	9 1/2					
30	5/8	1 7/16	2 1/2	3 15/16	5 5/8	7 11/16						
	11/16	1 1/2	2 5/8	4 1/8	5 15/16	8 1/16						
30	11/16	1 5/16	2 3/4	4 5/16	6 1/4	8 1/2						
	3/4	1 5/8	2 7/8	4 5/16	6 1/2	8 7/8						
30	3/4	1 11/16	3 1/16	4 3/4	6 11/16	9 5/16						
	13/16	1 3/4	3 5/16	4 11/16	7 1/8	9 11/16						
30	11/16	1 7/8	3 5/16	5 1/8	7 5/16							
	7/8	1 11/16	3 7/16	5 3/8	7 11/16							
30	7/8	2	3 5/8	5 5/16	8							
	15/16	2 1/16	3 11/16	5 3/4	8 5/16							
30	15/16	2 1/8	3 13/16	6	8 3/4							

TABLE XXVI.—INCHES IN DECIMALS OF A FOOT.

In.	0	1	2	3	4	5	6	7	8	9	10	11	In.
0	Feet	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167	0
1/32	.0026	.0859	.1693	.2526	.3359	.4193	.5026	.5859	.6693	.7526	.8359	.9193	1/32
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219	1/16
3/32	.0078	.0911	.1745	.2578	.3411	.4245	.5078	.5911	.6745	.7578	.8411	.9245	3/32
1/8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271	1/8
5/32	.0130	.0964	.1797	.2630	.3464	.4297	.5130	.5964	.6797	.7630	.8464	.9297	5/32
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323	3/16
7/32	.0182	.1016	.1849	.2682	.3516	.4349	.5182	.6016	.6849	.7682	.8516	.9349	7/32
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375	1/4
9/32	.0234	.1068	.1901	.2734	.3568	.4401	.5234	.6068	.6901	.7734	.8568	.9401	9/32
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427	5/16
11/32	.0286	.1120	.1953	.2786	.3620	.4453	.5286	.6120	.6953	.7786	.8620	.9453	11/32
3/8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479	3/8
13/32	.0339	.1172	.2005	.2839	.3672	.4505	.5339	.6172	.7005	.7839	.8672	.9505	13/32
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531	7/16
15/32	.0391	.1224	.2057	.2891	.3724	.4557	.5391	.6224	.7057	.7891	.8724	.9557	15/32
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583	1/2
17/32	.0443	.1276	.2109	.2943	.3776	.4609	.5443	.6276	.7109	.7943	.8776	.9609	17/32
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635	9/16
19/32	.0495	.1328	.2161	.2995	.3828	.4661	.5495	.6328	.7161	.7995	.8828	.9661	19/32
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688	5/8
21/32	.0547	.1380	.2214	.3047	.3880	.4714	.5547	.6380	.7214	.8047	.8880	.9714	21/32
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740	11/16
23/32	.0599	.1432	.2266	.3099	.3932	.4766	.5599	.6432	.7266	.8099	.8932	.9766	23/32
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792	3/4
25/32	.0651	.1484	.2318	.3151	.3984	.4818	.5651	.6484	.7318	.8151	.8984	.9818	25/32
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844	13/16
27/32	.0703	.1536	.2370	.3203	.4036	.4870	.5703	.6536	.7370	.8203	.9036	.9870	27/32
7/8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896	7/8
29/32	.0755	.1589	.2422	.3255	.4089	.4922	.5755	.6589	.7422	.8255	.9089	.9922	29/32
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948	15/16
31/32	.0807	.1641	.2474	.3307	.4141	.4974	.5807	.6641	.7474	.8307	.9141	.9974	31/32
In.	0	1	2	3	4	5	6	7	8	9	10	11	In.

TABLE XXVII.—MIDDLE ORDINATES FOR CURVING RAILS.

Deg. of Curve	Length of Rail										
	20	22	24	26	27	28	29	30	33	45	60
0°30′	1/16″	1/16″	1/16″	1/16″	1/8″	1/8″	1/8″	1/8″	1/8″	1/4″	1/4″
1	1/8	1/8	1/8	3/16	3/16	3/16	1/4	1/4	5/16	1/2	1 5/8
1 30	3/16	3/16	1/4	1/4	1/4	5/16	5/16	3/8	7/16	1 3/8	1 7/8
2	3/16	1/4	5/16	3/8	3/8	7/16	7/16	1/2	9/16	1 1/8	2 1/8
2 30	1/4	5/16	3/8	7/16	1/2	1/2	9/16	9/16	1 1/16	1 5/8	2 3/8
3	5/16	3/8	7/16	1/2	9/16	5/8	1 1/16	1 1/16	7/8	1 7/8	2 1/2
3 30	3/8	7/16	1/2	5/8	1 1/16	1 1/16	3/4	1 3/16	1	2 1/8	3 1/16
4	7/16	1/2	5/8	1 1/16	3/4	1 3/16	7/8	1 3/16	1 1/8	2 1/2	3 3/4
4 30	1/2	9/16	1 1/16	1 3/16	7/8	1 5/16	1	1 5/16	1 5/16	2 3/8	4 1/4
5	1/2	5/8	3/4	7/8	1 5/16	1	1 1/8	1 5/16	1 7/16	2 5/8	4 11/16
5 30	9/16	1 1/16	1 3/16	1	1 1/16	1 1/8	1 3/16	1 5/16	1 7/16	2 11/16	5 1/16
6	5/8	3/4	7/8	1 1/16	1 1/8	1 1/4	1 5/16	1 7/16	1 11/16	3 1/16	5 5/8
6 30	1 1/16	1 1/16	1	1 1/8	1 1/4	1 5/16	1 7/16	1 5/16	1 5/8	3 1/16	6 1/8
7	3/4	7/8	1 1/16	1 1/4	1 5/16	1 7/16	1 5/16	1 5/8	2	3 1/16	6 5/8
7 30	1 1/16	1 1/16	1 1/8	1 5/16	1 7/16	1 5/16	1 5/8	1 3/4	2 1/8	4	7 1/16
8	1 1/16	1	1 1/16	1 7/16	1 1/2	1 5/8	1 3/4	1 7/8	2 1/4	4 1/4	7 9/16
8 30	1 1/8	1 1/16	1 5/16	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/16	4 1/2	8
9	1 1/16	1 1/8	1 3/8	1 5/16	1 11/16	1 7/8	2	2 1/8	2 3/16	4 3/4	8 1/2
9 30	1	1 1/16	1 1/16	1 11/16	1 13/16	1 11/16	2 1/16	2 1/4	2 11/16	5 1/16	8 15/16
10	1 1/16	1 1/4	1 1/2	1 3/4	1 15/16	2 1/16	2 1/16	2 3/8	2 5/8	5 5/16	9 7/16
10 30	1 1/8	1 1/16	1 9/16	1 7/8	2	2 1/8	2 1/16	2 1/2	3	5 9/16	9 7/8
11	1 1/8	1 3/8	1 11/16	1 15/16	2 1/8	2 1/4	2 7/16	2 5/8	3 1/8	5 13/16	10 3/8
11 30	1 3/16	1 7/16	1 3/4	2	2 1/16	2 3/8	2 1/16	2 11/16	3 1/4	6 1/4	10 13/16
12	1 1/4	1 1/2	1 13/16	2 1/8	2 1/16	2 1/16	2 3/8	2 13/16	3 7/16	6 3/8	11 1/16
12 30	1 5/16	1 5/16	1 7/8	2 1/16	2 3/8	2 5/16	2 1/4	2 15/16	3 5/8	6 5/8	11 3/4
13	1 3/8	1 5/8	1 15/16	2 5/16	2 1/2	2 11/16	2 5/8	3 1/16	3 11/16	6 7/8	12 1/4
13 30	1 7/16	1 11/16	2 1/16	2 3/8	2 5/16	2 1/2	3	3 1/16	3 13/16	7 1/8	12 3/4
14	1 7/16	1 3/4	2 1/8	2 1/2	2 11/16	2 5/8	3 1/16	3 1/16	4	7 7/16	13 1/16
14 30	1 1/2	1 13/16	2 3/16	2 5/16	2 3/4	3	3 1/16	3 7/16	4 1/8	7 11/16	13 9/16

TABLE XXVIII. — STADIA REDUCTIONS

VERTICAL HEIGHTS

Minutes	0°	1°	2°	3°	4°	5°	6°	7°	8°
0	0.00	1.74	3.49	5.23	6.96	8.68	10.40	12.10	13.78
2	0.06	1.80	3.55	5.28	7.02	8.74	10.45	12.15	13.84
4	0.12	1.86	3.60	5.34	7.07	8.80	10.51	12.21	13.89
6	0.17	1.92	3.66	5.40	7.13	8.85	10.57	12.26	13.95
8	0.23	1.98	3.72	5.46	7.19	8.91	10.62	12.32	14.01
10	0.29	2.04	3.78	5.52	7.25	8.97	10.68	12.38	14.06
12	0.35	2.09	3.84	5.57	7.30	9.03	10.74	12.43	14.12
14	0.41	2.15	3.90	5.63	7.36	9.08	10.79	12.49	14.17
16	0.47	2.21	3.95	5.69	7.42	9.14	10.85	12.55	14.23
18	0.52	2.27	4.01	5.75	7.48	9.20	10.91	12.60	14.28
20	0.58	2.33	4.07	5.80	7.53	9.25	10.96	12.66	14.34
22	0.64	2.38	4.13	5.86	7.59	9.31	11.02	12.72	14.40
24	0.70	2.44	4.18	5.92	7.65	9.37	11.08	12.77	14.45
26	0.76	2.50	4.24	5.98	7.71	9.43	11.13	12.83	14.51
28	0.81	2.56	4.30	6.04	7.76	9.48	11.19	12.88	14.56
30	0.87	2.62	4.36	6.09	7.82	9.54	11.25	12.94	14.62
32	0.93	2.67	4.42	6.15	7.88	9.60	11.30	13.00	14.67
34	0.99	2.73	4.48	6.21	7.94	9.65	11.36	13.05	14.73
36	1.05	2.79	4.53	6.27	7.99	9.71	11.42	13.11	14.79
38	1.11	2.85	4.59	6.33	8.05	9.77	11.47	13.17	14.84
40	1.16	2.91	4.65	6.38	8.11	9.83	11.53	13.22	14.90
42	1.22	2.97	4.71	6.44	8.17	9.88	11.59	13.28	14.95
44	1.28	3.02	4.76	6.50	8.22	9.94	11.64	13.33	15.01
46	1.34	3.08	4.82	6.56	8.28	10.00	11.70	13.39	15.06
48	1.40	3.14	4.88	6.61	8.34	10.05	11.76	13.45	15.12
50	1.45	3.20	4.94	6.67	8.40	10.11	11.81	13.50	15.17
52	1.51	3.26	4.99	6.73	8.45	10.17	11.87	13.56	15.23
54	1.57	3.31	5.05	6.79	8.51	10.22	11.93	13.61	15.28
56	1.63	3.37	5.11	6.84	8.57	10.28	11.98	13.67	15.34
58	1.69	3.43	5.17	6.90	8.63	10.34	12.04	13.73	15.40
60	1.74	3.49	5.23	6.96	8.68	10.40	12.10	13.78	15.45

HORIZONTAL CORRECTIONS

Dist.	0°	1°	2°	3°	4°	5°	6°	7°	8°
100	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9
200	0.0	0.1	0.2	0.5	1.0	1.5	2.2	3.0	3.9
300	0.0	0.1	0.4	0.8	1.5	2.3	3.3	4.5	5.8
400	0.0	0.1	0.5	1.1	2.0	3.0	4.4	6.0	7.8
500	0.0	0.2	0.6	1.4	2.5	3.8	5.5	7.5	9.7
600	0.0	0.2	0.7	1.6	2.9	4.6	6.5	8.9	11.6
700	0.0	0.2	0.8	1.9	3.4	5.3	7.6	10.4	13.6
800	0.0	0.2	1.0	2.2	3.9	6.1	8.7	11.9	15.5
900	0.0	0.3	1.1	2.4	4.4	6.8	9.8	13.4	17.5
1000	0.0	0.3	1.2	2.7	4.9	7.6	10.9	14.9	19.4

TABLE XXVIII. — STADIA REDUCTIONS

VERTICAL HEIGHTS

10°	11°	12°	13°	14°	15°	16°	17°	18°	19°
17.10	18.73	20.34	21.92	23.47	25.00	26.50	27.96	29.39	30.78
17.16	18.78	20.39	21.97	23.52	25.05	26.55	28.01	29.44	30.83
17.21	18.84	20.44	22.02	23.58	25.10	26.59	28.06	29.48	30.87
17.26	18.89	20.50	22.08	23.63	25.15	26.64	28.10	29.53	30.92
17.32	18.95	20.55	22.13	23.68	25.20	26.69	28.15	29.58	30.97
17.37	19.00	20.60	22.18	23.73	25.25	26.74	28.20	29.62	31.01
17.43	19.05	20.66	22.23	23.78	25.30	26.79	28.25	29.67	31.06
17.48	19.11	20.71	22.28	23.83	25.35	26.84	28.30	29.72	31.10
17.54	19.16	20.76	22.34	23.88	25.40	26.89	28.34	29.76	31.15
17.59	19.21	20.81	22.39	23.93	25.45	26.94	28.39	29.81	31.19
17.65	19.27	20.87	22.44	23.99	25.50	26.99	28.44	29.86	31.24
17.70	19.32	20.92	22.49	24.04	25.55	27.04	28.49	29.90	31.28
17.76	19.38	20.97	22.54	24.09	25.60	27.09	28.54	29.95	31.33
17.81	19.43	21.03	22.60	24.14	25.65	27.13	28.58	30.00	31.38
17.86	19.48	21.08	22.65	24.19	25.70	27.18	28.63	30.04	31.42
17.92	19.54	21.13	22.70	24.24	25.75	27.23	28.68	30.09	31.47
17.97	19.59	21.18	22.75	24.29	25.80	27.28	28.73	30.14	31.51
18.03	19.64	21.24	22.80	24.34	25.85	27.33	28.77	30.19	31.56
18.08	19.70	21.29	22.85	24.39	25.90	27.38	28.82	30.23	31.60
18.14	19.75	21.34	22.91	24.44	25.95	27.43	28.87	30.28	31.65
18.19	19.80	21.39	22.96	24.49	26.00	27.48	28.92	30.32	31.69
18.24	19.86	21.45	23.01	24.55	26.05	27.52	28.96	30.37	31.74
18.30	19.91	21.50	23.06	24.60	26.10	27.57	29.01	30.41	31.78
18.35	19.96	21.55	23.11	24.65	26.15	27.62	29.06	30.46	31.83
18.41	20.02	21.60	23.16	24.70	26.20	27.67	29.11	30.51	31.87
18.46	20.07	21.66	23.22	24.75	26.25	27.72	29.15	30.55	31.92
18.51	20.12	21.71	23.27	24.80	26.30	27.77	29.20	30.60	31.96
18.57	20.18	21.76	23.32	24.85	26.35	27.81	29.25	30.65	32.01
18.62	20.23	21.81	23.37	24.90	26.40	27.86	29.30	30.69	32.05
18.68	20.28	21.87	23.42	24.95	26.45	27.91	29.34	30.74	32.09
18.73	20.34	21.92	23.47	25.00	26.50	27.96	29.39	30.78	32.14

HORIZONTAL CORRECTIONS

st.	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°
00	3.0	3.6	4.3	5.1	5.9	6.7	7.6	8.5	9.5	10.6
00	6.0	7.3	8.6	10.1	11.7	13.4	15.2	17.1	19.1	21.2
00	9.1	10.9	13.0	15.2	17.6	20.1	22.8	25.6	28.6	31.8
00	12.1	14.6	17.3	20.2	23.4	26.8	30.4	34.2	38.2	42.4
00	15.1	18.2	21.6	25.3	29.3	33.5	38.0	42.7	47.7	53.0
00	18.1	21.8	25.9	30.4	35.1	40.2	45.6	51.3	57.3	63.6
00	21.1	25.5	30.2	35.4	41.0	46.9	53.2	59.8	66.8	74.2
00	24.2	29.1	34.6	40.5	46.8	53.6	60.8	68.4	76.4	84.8
00	27.2	32.8	38.9	45.5	52.7	60.3	68.4	76.9	85.9	95.4
00	30.2	36.4	43.2	50.6	58.5	67.0	76.0	85.5	95.5	106.0

TABLE XXVIII. — STADIA REDUCTIONS

VERTICAL HEIGHTS

Minutes	20°	21°	22°	23°	24°	25°	26°	27°	2
0	32.14	33.46	34.73	35.97	37.16	38.30	39.40	40.45	41
2	32.18	33.50	34.77	36.01	37.20	38.34	39.44	40.49	41
4	32.23	33.54	34.82	36.05	37.23	38.38	39.47	40.52	41
6	32.27	33.59	34.86	36.09	37.27	38.41	39.51	40.55	41
8	32.32	33.63	34.90	36.13	37.31	38.45	39.54	40.59	41
10	32.36	33.67	34.94	36.17	37.35	38.49	39.58	40.62	41
12	32.41	33.72	34.98	36.21	37.39	38.53	39.61	40.66	41
14	32.45	33.76	35.02	36.25	37.43	38.56	39.65	40.69	41
16	32.49	33.80	35.07	36.29	37.47	38.60	39.69	40.72	41
18	32.54	33.84	35.11	36.33	37.51	38.64	39.72	40.76	41
20	32.58	33.89	35.15	36.37	37.54	38.67	39.76	40.79	41
22	32.63	33.93	35.19	36.41	37.58	38.71	39.79	40.82	41
24	32.67	33.97	35.23	36.45	37.62	38.75	39.83	40.86	41
26	32.72	34.01	35.27	36.49	37.66	38.78	39.86	40.89	41
28	32.76	34.06	35.31	36.53	37.70	38.82	39.90	40.92	41
30	32.80	34.10	35.36	36.57	37.74	38.86	39.93	40.96	41
32	32.85	34.14	35.40	36.61	37.77	38.89	39.97	40.99	41
34	32.89	34.18	35.44	36.65	37.81	38.93	40.00	41.02	42
36	32.93	34.23	35.48	36.69	37.85	38.97	40.04	41.06	42
38	32.98	34.27	35.52	36.73	37.89	39.00	40.07	41.09	42
40	33.02	34.31	35.56	36.77	37.93	39.04	40.11	41.12	42
42	33.07	34.35	35.60	36.80	37.96	39.08	40.14	41.16	42
44	33.11	34.40	35.64	36.84	38.00	39.11	40.18	41.19	42
46	33.15	34.44	35.68	36.88	38.04	39.15	40.21	41.22	42
48	33.20	34.48	35.72	36.92	38.08	39.18	40.24	41.26	42
50	33.24	34.52	35.76	36.96	38.11	39.22	40.28	41.29	42
52	33.28	34.57	35.80	37.00	38.15	39.26	40.31	41.32	42
54	33.33	34.61	35.85	37.04	38.19	39.29	40.35	41.35	42
56	33.37	34.65	35.89	37.08	38.23	39.33	40.38	41.39	42
58	33.41	34.69	35.93	37.12	38.26	39.36	40.42	41.42	42
60	33.46	34.73	35.97	37.16	38.30	39.40	40.45	41.45	42

HORIZONTAL CORRECTIONS

Dist.	20°	21°	22°	23°	24°	25°	26°	27°	2
100	11.7	12.8	14.0	15.3	16.5	17.9	19.2	20.6	2
200	23.4	25.7	28.1	30.5	33.1	35.7	38.4	41.2	4
300	35.1	38.5	42.1	45.8	49.6	53.6	57.7	61.8	6
400	46.8	51.4	56.1	61.1	66.2	71.4	76.9	82.4	8
500	58.5	64.2	70.2	76.4	82.7	89.3	96.1	103.1	11
600	70.2	77.0	84.2	91.6	99.2	107.2	115.3	123.7	13
700	81.9	89.9	98.2	106.9	115.8	125.0	134.5	144.3	15
800	93.6	102.7	112.2	122.2	132.3	142.9	153.8	164.9	17
900	105.3	115.6	126.3	137.4	148.9	160.7	173.0	185.5	19
1000	117.0	128.4	140.3	152.7	165.4	178.6	192.2	206.1	21

TABLE XXIX.—MEAN REFRACTIONS IN DECLINATION.

Hour Ang.	DECLINATIONS.								
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
0 h	−18″	−12″	−07″	−02″	02″	07″	12″	18″	23″
2	−18	−12	−07	−02	02	07	12	18	23
3	−17	−11	−06	−01	03	08	13	19	25
4	−15	−10	−05	00	05	10	15	21	27
5	−10	−05	00	+05	10	15	20	26	32
0 h	−15″	−10″	−05″	00″	05″	10″	15″	20″	27″
2	−15	−10	−05	00	05	10	15	20	27
3	−13	−08	−03	+02	07	12	17	23	29
4	−10	−05	00	+05	10	15	20	27	32
5	−05	00	+05	+10	15	20	27	32	40
0 h	−13″	−08″	−02″	02″	08″	13″	18″	24″	29″
2	−12	−07	−01	03	09	14	19	25	31
3	−10	−05	00	05	10	15	20	26	32
4	−05	00	+05	10	15	20	26	32	39
5	+07	+12	+17	23	29	36	43	51	1′01
0 h	−10″	−05″	00″	05″	10″	15″	20″	26″	32″
2	−07	−03	02	07	12	17	22	28	34
3	−05	00	03	08	13	19	25	31	38
4	00	+05	10	15	20	26	32	39	46
5	+15	+20	26	32	39	46	55	1′06	1′19
0 h	−08″	−02″	02″	08″	13″	18″	24″	30″	36″
2	−06	00	05	10	15	20	26	32	39
3	+02	+07	12	17	23	29	36	43	51
4	+04	+09	14	20	25	31	40	48	55
5	+21	+27	33	40	48	57	1′08	1′23	1′41
0 h	−05″	00″	05″	10″	15″	21″	27″	33″	40″
2	−03	02	07	12	18	23	29	36	43
3	+01	05	11	16	22	28	34	41	49
4	+08	12	19	24	30	37	44	53	1′04
5	+29	34	41	49	59	1′10	1′24	1′43	2 08
0 h	−02″	02″	08″	13″	18″	24″	30″	36″	44″
2	00	05	10	15	21	27	33	40	48
3	+02	10	15	21	27	33	40	48	57
4	+13	18	23	29	35	43	51	1′01	1′13
5	+34	41	49	58	1′10	1′23	1′41	2 06	2 42
0 h	00″	05″	10″	15″	21″	27″	33″	40″	48″
2	03	07	13	18	24	30	36	44	52
3	06	13	18	24	30	36	44	52	1′02
4	17	22	28	35	42	50	1′00	1′11	1 26
5	39	47	57	1′07	1′20	1′37	2 00	2 32	3 25
0 h	02″	08″	13″	18″	24″	30″	36″	44″	52″
2	06	11	15	21	27	33	40	48	57
3	11	15	21	27	33	40	48	57	1′08
4	20	26	32	39	46	56	1′07	1′19	1 37
5	45	53	1′03	1′16	1′31	1′52	2 21	3 07	4 28
0 h	05″	10″	15″	21″	27″	33″	40″	48″	57″
2	08	14	19	25	31	38	46	54	1′05
3	12	18	24	30	37	44	53	1′04	1 18
4	23	29	35	45	53	1′03	1′16	1 31	1 52
5	49	59	1′10	1′24	1′52	2 07	2 44	3 46	5 43
	+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°

TABLE XXIX.—MEAN REFRACTIONS IN DECLINA

Latitude.	Hour Ang.	DECLINATIONS.							
		+20°	+15°	+10°	+5°	0°	−5°	−10°	−
27°30′	0h	08″	13″	18″	24″	30″	36″	44″	
	2	11	16	22	28	34	41	49	1
	3	17	22	28	35	42	50	1′00	1
	4	28	35	42	50	1′00	1′11	1 26	1
	5	54	1′05	1′18	1′34	1 54	2 24	3 11	4
30°	0h	10″	15″	21″	27″	33″	40″	48″	
	2	14	19	25	31	38	46	54	1
	3	20	26	32	39	47	55	1′06	1
	4	32	39	46	52	1′06	1′19	1 35	1
	5	1′00	1′10	1′24	1′52	2 07	2 44	3 46	5
32°30′	0h	13″	18″	24″	30″	36″	44″	52″	1
	2	17	22	28	35	42	50	1′00	1
	3	23	29	35	43	51	1′01	1 13	1
	4	35	43	51	1′01	1′13	1 27	1 46	2
	5	1′03	1′15	1′31	1 53	2 20	3 05	4 25	7
35°	0h	15″	21″	27″	33″	40″	48″	57″	1
	2	20	25	32	38	46	55	1′05	1
	3	26	33	39	47	56	1′07	1 21	1
	4	39	47	56	1′07	1′20	1 36	1 59	2
	5	1′07	1′20	1′38	2 00	2 34	3 29	5 14	10
37°30′	0h	18″	24″	30″	36″	44″	52″	1′02″	1′
	2	22	28	35	42	50	1′00	1 12	1
	3	29	36	43	52	1′02	1 14	1 29	1
	4	43	51	1′01	1′13	1 27	1 49	2 14	2
	5	1′11	1′26	1 54	2 10	2 49	3 55	6 15	14
40°	0h	21″	27″	33″	40″	48″	57″	1′08″	1
	2	25	32	39	46	52	1′06	1 19	1
	3	33	40	48	57	1′08	1 21	1 38	2
	4	47	55	1′06	1′19	1 36	1 58	2 30	3
	5	1′15	1′31	1 51	2 20	3 05	4 25	7 34	25
42°30′	0h	24″	30″	36″	44″	52″	1′02″	1′14″	1
	2	28	35	39	50	1′00	1 12	1 26	1
	3	36	43	52	1′02	1 13	1 29	1 49	2
	4	50	1′00	1′11	1 26	1 44	2 10	2 49	3
	5	1′19	1 36	1 58	2 30	3 22	5 00	9 24	
45°	0h	27″	33″	40″	48″	57″	1′08″	1′21″	1
	2	32	39	46	52	1′06	1 19	1 35	1
	3	40	47	56	1′07	1 21	1 38	2 00	2
	4	54	1′04	1′16	1 33	1 54	2 24	3 11	4
	5	1′23	1 41	2 05	2 41	3 40	5 40	12 02	
47°30′	0h	30″	36″	44″	52″	1′02″	1′14″	1′29″	1
	2	35	42	50	1′00	1 12	1 26	1 45	2
	3	43	51	1′01	1 13	1 28	1 47	2 15	2
	4	56	1′09	1 23	1 40	2 05	2 40	3 39	5
	5	1′27	1 46	2 12	2 52	4 01	6 30	16 19	
		+20°	+15°	+10°	+5°	0°	−5°	−10°	−

TABLE XXIX.—MEAN REFRACTIONS IN DECLINATION.

Latitude.	Hour Ang.	DECLINATIONS.								
		+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°
50°	0 h	33″	40″	48″	57″	1′08″	1′21″	1′39″	2′02″	2′36″
	2	38	46	55	1′06	1 18	1 35	1 57	2 28	3 19
	3	47	56	1′06	1 19	1 36	2 29	2 31	3 23	5 02
	4	1′02	1′14	1 29	1 48	2 16	2 58	4 18	6 59	19 47
	5	1 30	1 51	2 19	3 04	4 22	7 28	24 10		
52°30′	0 h	36″	44″	52″	1′02″	1′14″	1′29″	1′49″	2′18″	3′05″
	2	43	50	59	1 11	1 26	1 42	2 23	2 49	3 55
	3	50	1′00	1′11	1 26	1 45	2 11	2 51	2 58	6 22
	4	1′05	1 18	1 35	2 10	2 28	3 19	4 53	8 42	
	5	1 34	1 56	2 27	3 16	4 47	8 52			
55°	0 h	40″	48″	57″	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″
	2	46	55	1′05	1 18	1 34	1 56	2 30	3 15	4 47
	3	55	1′06	1 19	1 35	1 58	2 30	3 21	4 58	9 19
	4	1′10	1 23	1 42	2 06	2 43	3 44	5 49	12 41	
	5	1 37	2 01	2 34	3 28	5 15	10 18			
57°30′	0 h	44″	52″	1′02″	1′14″	1′29″	1′49″	2′18″	3′05″	4 37″
	2	50	59	1 11	1 25	1 43	2 09	2 47	3 51	6 04
	3	58	1′10	1 24	1 42	2 07	2 43	3 45	5 50	12 47
	4	1′11	1 25	1 43	2 10	2 50	3 55	6 14	14 49	
	5	1 41	2 06	2 42	3 42	5 46	12 26			
60°	0 h	48″	57″	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″	5′23″
	2	54	1′04	1 17	1 33	1 54	2 24	3 12	4 38	8 15
	3	1′03	1 15	1 30	1 51	2 20	3 04	4 24	7 31	24 44
	4	1 18	1 34	1 56	2 28	3 18	4 50	8 53		
	5	1 45	2 11	2 50	3 57	6 21	15 32			
62°30′	0 h	52″	1′02″	1′14″	1′29″	1′50″	2′18″	3′00″	4′17″	7′13″
	2	58	1 09	1 23	1 41	2 06	2 43	3 44	5 50	12 44
	3	1′07	1 23	1 38	2 01	2 35	3 30	5 16	10 24	
	4	1 23	1 40	2 05	2 40	3 40	5 37	11 50		
	5	1 48	2 17	2 59	4 14	7 03				
65°	0 h	57″	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″	5′23″	10′51″
	2	1′03	1 16	1 31	1 52	2 21	3 07	4 28	7 44	
	3	1 12	1 27	1 46	2 12	2 52	4 02	6 33		
	4	1 27	1 47	2 13	2 54	4 05	6 40			
	5	1 52	2 22	3 08	4 30	7 52				
67°30′	0 h	1′02″	1′14″	1′29″	1′50″	2′18″	3′00″	4′17″	7′13″	
	2	1 08	1 22	1 40	2 03	2 39	3 37	5 32	11 28	
	3	1 17	1 34	1 55	2 26	3 14	4 44	8 34		
	4	1 32	1 53	2 23	3 14	4 35	8 05			
	5	1 56	2 28	3 17	4 40	8 51				
70°	0 h	1′08″	1′21″	1′39″	2′02″	2′36″	3′33″	5′23″	10′51″	
	2	1 14	1 29	1 50	2 18	3 00	4 17	7 13		
	3	1 23	1 43	2 05	2 41	3 41	5 59	12 15		
	4	1 37	2 00	2 34	3 28	5 20	10 12			
	5	2 02	2 33	3 27	5 11	10 05				
		+20°	+15°	+10°	+5°	0°	−5°	−10°	−15°	−20°

	WIDTH								
Hght	1	2	3	4	5	6	7	8	9
0.1	.09	.19	.28	.37	.46	.56	.65	.74	.
.2	.19	.37	.56	.74	.93	1.11	1.30	1.48	1.
.3	.28	.56	.83	1.11	1.39	1.67	1.94	2.22	2.
.4	.37	.74	1.11	1.48	1.85	2.22	2.59	2.96	3.
0.5	.46	.93	1.39	1.85	2.31	2.78	3.24	3.70	4.
.6	.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.
.7	.65	1.30	1.94	2.59	3.24	3.89	4.54	5.19	5.
.8	.74	1.48	2.22	2.96	3.70	4.44	5.19	5.93	6.
.9	.83	1.67	2.50	3.33	4.17	5.00	5.83	6.67	7.
1.0	.93	1.85	2.78	3.70	4.63	5.56	6.48	7.41	8.
.1	1.02	2.04	3.06	4.07	5.09	6.11	7.13	8.15	9.
.2	1.11	2.22	3.33	4.44	5.56	6.67	7.78	8.89	10.
.3	1.20	2.41	3.61	4.81	6.02	7.22	8.43	9.63	10.
.4	1.30	2.59	3.89	5.19	6.48	7.78	9.07	10.37	11.
1.5	1.39	2.78	4.17	5.56	6.94	8.33	9.72	11.11	12.
.6	1.48	2.96	4.44	5.93	7.41	8.89	10.37	11.85	13.
.7	1.57	3.15	4.72	6.30	7.87	9.44	11.02	12.59	14.
.8	1.67	3.33	5.00	6.67	8.33	10.00	11.67	13.33	15.
.9	1.76	3.52	5.28	7.04	8.80	10.56	12.31	14.07	15.
2.0	1.85	3.70	5.56	7.41	9.26	11.11	12.96	14.81	16.
.1	1.94	3.89	5.83	7.78	9.72	11.67	13.61	15.56	17.
.2	2.04	4.07	6.11	8.15	10.19	12.22	14.26	16.30	18.
.3	2.13	4.26	6.39	8.52	10.65	12.78	14.91	17.04	19.
.4	2.22	4.44	6.67	8.89	11.11	13.33	15.56	17.78	20.
2.5	2.31	4.63	6.94	9.26	11.57	13.89	16.20	18.52	20.
.6	2.41	4.81	7.22	9.63	12.04	14.44	16.85	19.26	21.
.7	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.
.8	2.59	5.19	7.78	10.37	12.96	15.56	18.15	20.74	23.
.9	2.69	5.37	8.06	10.74	13.43	16.11	18.80	21.48	24.
3.0	2.78	5.56	8.33	11.11	13.89	16.67	19.44	22.22	25.
.1	2.87	5.74	8.61	11.48	14.35	17.22	20.09	22.96	25.
.2	2.96	5.93	8.89	11.85	14.81	17.78	20.74	23.70	26.
.3	3.06	6.11	9.17	12.22	15.28	18.33	21.39	24.44	27.
.4	3.15	6.30	9.44	12.59	15.74	18.89	22.04	25.19	28.
3.5	3.24	6.48	9.72	12.96	16.20	19.44	22.69	25.93	29.
.6	3.33	6.67	10.00	13.33	16.67	20.00	23.33	26.67	30.
.7	3.43	6.85	10.28	13.70	17.13	20.56	23.98	27.41	30.
.8	3.52	7.04	10.56	14.07	17.59	21.11	24.63	28.15	31.
.9	3.61	7.22	10.83	14.44	18.06	21.67	25.28	28.89	32.
4.0	3.70	7.41	11.11	14.81	18.52	22.22	25.93	29.63	33.
.1	3.80	7.59	11.39	15.19	18.98	22.78	26.57	30.37	34.
.2	3.89	7.78	11.67	15.56	19.44	23.33	27.22	31.11	35.
.3	3.98	7.96	11.94	15.93	19.91	23.89	27.87	31.85	35.
.4	4.07	8.15	12.22	16.30	20.37	24.44	28.52	32.59	36.
4.5	4.17	8.33	12.50	16.67	20.83	25.00	29.17	33.33	37.
.6	4.26	8.52	12.78	17.04	21.30	25.56	29.81	34.07	38.
.7	4.35	8.70	13.06	17.41	21.76	26.11	30.46	34.81	39.
.8	4.44	8.89	13.33	17.78	22.22	26.67	31.11	35.56	40.
.9	4.54	9.07	13.61	18.15	22.69	27.22	31.76	36.30	40.
5.0	4.63	9.26	13.89	18.52	23.15	27.78	32.41	37.04	41.
.1	4.72	9.44	14.17	18.89	23.61	28.33	33.06	37.78	42.
.2	4.81	9.63	14.44	19.26	24.07	28.89	33.70	38.52	43.
.3	4.91	9.81	14.72	19.63	24.54	29.44	34.35	39.26	44.
.4	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.
5.5	5.09	10.19	15.28	20.37	25.46	30.56	35.65	40.74	45.
.6	5.19	10.37	15.56	20.74	25.93	31.11	36.30	41.48	46.
.7	5.28	10.56	15.83	21.11	26.39	31.67	36.94	42.22	47.
.8	5.37	10.74	16.11	21.48	26.85	32.22	37.59	42.96	48.
.9	5.46	10.93	16.39	21.85	27.31	32.78	38.24	43.70	49.
	1	2	3	4	5	6	7	8	9

TABLE XXX.—TRIANGULAR PRISMS. CU. YDS. PER 50 FEET.

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
6.0	5.56	11.11	16.67	22.22	27.78	33.33	38.89	44.44	50.00	6.0
.1	5.65	11.30	16.94	22.59	28.24	33.89	39.54	45.19	50.83	.1
.2	5.74	11.48	17.22	22.96	28.70	34.44	40.19	45.93	51.67	.2
.3	5.83	11.67	17.50	23.33	29.17	35.00	40.83	46.67	52.50	.3
.4	5.93	11.85	17.78	23.70	29.63	35.56	41.48	47.41	53.33	.4
6.5	6.02	12.04	18.06	24.07	30.09	36.11	42.13	48.15	54.17	6.5
.6	6.11	12.22	18.33	24.44	30.56	36.67	42.78	48.89	55.00	.6
.7	6.20	12.41	18.61	24.81	31.02	37.22	43.43	49.63	55.83	.7
.8	6.30	12.59	18.89	25.19	31.48	37.78	44.07	50.37	56.67	.8
.9	6.39	12.78	19.17	25.56	31.94	38.33	44.72	51.11	57.50	.9
7.0	6.48	12.96	19.44	25.93	32.41	38.89	45.37	51.85	58.33	7.0
.1	6.57	13.15	19.72	26.30	32.87	39.44	46.02	52.59	59.17	.1
.2	6.67	13.33	20.00	26.67	33.33	40.00	46.67	53.33	60.00	.2
.3	6.76	13.52	20.28	27.04	33.80	40.56	47.31	54.07	60.83	.3
.4	6.85	13.70	20.56	27.41	34.26	41.11	47.96	54.81	61.67	.4
7.5	6.94	13.89	20.83	27.78	34.72	41.67	48.61	55.56	62.50	7.5
.6	7.04	14.07	21.11	28.15	35.19	42.22	49.26	56.30	63.33	.6
.7	7.13	14.26	21.39	28.52	35.65	42.78	49.91	57.04	64.17	.7
.8	7.22	14.44	21.67	28.89	36.11	43.33	50.56	57.78	65.00	.8
.9	7.31	14.63	21.94	29.26	36.57	43.89	51.20	58.52	65.83	.9
8.0	7.41	14.81	22.22	29.63	37.04	44.44	51.85	59.26	66.67	8.0
.1	7.50	15.00	22.50	30.00	37.50	45.00	52.50	60.00	67.50	.1
.2	7.59	15.19	22.78	30.37	37.96	45.56	53.15	60.74	68.33	.2
.3	7.69	15.37	23.06	30.74	38.43	46.11	53.80	61.48	69.17	.3
.4	7.78	15.56	23.33	31.11	38.89	46.67	54.44	62.22	70.00	.4
8.5	7.87	15.74	23.61	31.48	39.35	47.22	55.09	62.96	70.83	8.5
.6	7.96	15.93	23.89	31.85	39.81	47.78	55.74	63.70	71.67	.6
.7	8.06	16.11	24.17	32.22	40.28	48.33	56.39	64.44	72.50	.7
.8	8.15	16.30	24.44	32.59	40.74	48.89	57.04	65.19	73.33	.8
.9	8.24	16.48	24.72	32.96	41.20	49.44	57.69	65.93	74.17	.9
9.0	8.33	16.67	25.00	33.33	41.67	50.00	58.33	66.67	75.00	9.0
.1	8.43	16.85	25.28	33.70	42.13	50.56	58.98	67.41	75.83	.1
.2	8.52	17.04	25.56	34.07	42.59	51.11	59.63	68.15	76.67	.2
.3	8.61	17.22	25.83	34.44	43.06	51.67	60.28	68.89	77.50	.3
.4	8.70	17.41	26.11	34.81	43.52	52.22	60.93	69.63	78.33	.4
9.5	8.80	17.59	26.39	35.19	43.98	52.78	61.57	70.37	79.17	9.5
.6	8.89	17.78	26.67	35.56	44.44	53.33	62.22	71.11	80.00	.6
.7	8.98	17.96	26.94	35.93	44.91	53.89	62.87	71.85	80.83	.7
.8	9.07	18.15	27.22	36.30	45.37	54.44	63.52	72.59	81.67	.8
.9	9.17	18.33	27.50	36.67	45.83	55.00	64.17	73.33	82.50	.9
10.0	9.26	18.52	27.78	37.04	46.30	55.56	64.81	74.07	83.33	10.0
.1	9.35	18.70	28.06	37.41	46.76	56.11	65.46	74.81	84.17	.1
.2	9.44	18.89	28.33	37.78	47.22	56.67	66.11	75.56	85.00	.2
.3	9.54	19.07	28.61	38.15	47.69	57.22	66.76	76.30	85.83	.3
.4	9.63	19.26	28.89	38.52	48.15	57.78	67.41	77.04	86.67	.4
10.5	9.72	19.44	29.17	38.89	48.61	58.33	68.06	77.78	87.50	10.5
.6	9.81	19.63	29.44	39.26	49.07	58.89	68.70	78.52	88.33	.6
.7	9.91	19.81	29.72	39.63	49.54	59.44	69.35	79.26	89.17	.7
.8	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	.8
.9	10.09	20.19	30.28	40.37	50.46	60.56	70.65	80.74	90.83	.9
11.0	10.19	20.37	30.56	40.74	50.93	61.11	71.30	81.48	91.67	11.0
.1	10.28	20.56	30.83	41.11	51.39	61.67	71.94	82.22	92.50	.1
.2	10.37	20.74	31.11	41.48	51.85	62.22	72.59	82.96	93.33	.2
.3	10.46	20.93	31.39	41.85	52.31	62.78	73.24	83.70	94.17	.3
.4	10.56	21.11	31.67	42.22	52.78	63.33	73.89	84.44	95.00	.4
11.5	10.65	21.30	31.94	42.59	53.24	63.89	74.54	85.19	95.83	11.5
.6	10.74	21.48	32.22	42.96	53.70	64.44	75.19	85.93	96.67	.6
.7	10.83	21.67	32.50	43.33	54.17	65.00	75.83	86.67	97.50	.7
.8	10.93	21.85	32.78	43.70	54.63	65.56	76.48	87.41	98.33	.8
.9	11.02	22.04	33.06	44.07	55.09	66.11	77.13	88.15	99.17	.9
	1	2	3	4	5	6	7	8	9	

TABLE XXX.—TRIANGULAR PRISMS. CU. YDS. PER 50 FEET.

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
12.0	11.11	22.22	33.33	44.44	55.56	66.67	77.78	88.89	100.00	12.0
.1	11.20	22.41	33.61	44.81	56.02	67.22	78.43	89.63	100.83	.1
.2	11.30	22.59	33.89	45.19	56.48	67.78	79.07	90.37	101.67	.2
.3	11.39	22.78	34.17	45.56	56.94	68.33	79.72	91.11	102.50	.3
.4	11.48	22.96	34.44	45.93	57.41	68.89	80.37	91.85	103.33	.4
12.5	11.57	23.15	34.72	46.30	57.87	69.44	81.02	92.59	104.17	12.5
.6	11.67	23.33	35.00	46.67	58.33	70.00	81.67	93.33	105.00	.6
.7	11.76	23.52	35.28	47.04	58.80	70.56	82.31	94.07	105.83	.7
.8	11.85	23.70	35.56	47.41	59.26	71.11	82.96	94.81	106.67	.8
.9	11.94	23.89	35.83	47.78	59.72	71.67	83.61	95.56	107.50	.9
13.0	12.04	24.07	36.11	48.15	60.19	72.22	84.26	96.30	108.33	13.0
.1	12.13	24.26	36.39	48.52	60.65	72.78	84.91	97.04	109.17	.1
.2	12.22	24.44	36.67	48.89	61.11	73.33	85.56	97.78	110.00	.2
.3	12.31	24.63	36.94	49.26	61.57	73.89	86.20	98.52	110.83	.3
.4	12.41	24.81	37.22	49.63	62.04	74.44	86.85	99.26	111.67	.4
13.5	12.50	25.00	37.50	50.00	62.50	75.00	87.50	100.00	112.50	13.5
.6	12.59	25.19	37.78	50.37	62.96	75.56	88.15	100.74	113.33	.6
.7	12.69	25.37	38.06	50.74	63.43	76.11	88.80	101.48	114.17	.7
.8	12.78	25.56	38.33	51.11	63.89	76.67	89.44	102.22	115.00	.8
.9	12.87	25.74	38.61	51.48	64.35	77.22	90.09	102.96	115.83	.9
14.0	12.96	25.93	38.89	51.85	64.81	77.78	90.74	103.70	116.67	14.0
.1	13.06	26.11	39.17	52.22	65.28	78.33	91.39	104.44	117.50	.1
.2	13.15	26.30	39.44	52.59	65.74	78.89	92.04	105.19	118.33	.2
.3	13.24	26.48	39.72	52.96	66.20	79.44	92.69	105.93	119.17	.3
.4	13.33	26.67	40.00	53.33	66.67	80.00	93.33	106.67	120.00	.4
14.5	13.43	26.85	40.28	53.70	67.13	80.56	93.98	107.41	120.83	14.5
.6	13.52	27.04	40.56	54.07	67.59	81.11	94.63	108.15	121.67	.6
.7	13.61	27.22	40.83	54.44	68.06	81.67	95.28	108.89	122.50	.7
.8	13.70	27.41	41.11	54.81	68.52	82.22	95.93	109.63	123.33	.8
.9	13.80	27.59	41.39	55.19	68.98	82.78	96.57	110.37	124.17	.9
15.0	13.89	27.78	41.67	55.56	69.44	83.33	97.22	111.11	125.00	15.0
.1	13.98	27.96	41.94	55.93	69.91	83.89	97.87	111.85	125.83	.1
.2	14.07	28.15	42.22	56.30	70.37	84.44	98.52	112.59	126.67	.2
.3	14.17	28.33	42.50	56.67	70.83	85.00	99.17	113.33	127.50	.3
.4	14.26	28.52	42.78	57.04	71.30	85.56	99.81	114.07	128.33	.4
15.5	14.35	28.70	43.06	57.41	71.76	86.11	100.46	114.81	129.17	15.5
.6	14.44	28.89	43.33	57.78	72.22	86.67	101.11	115.56	130.00	.6
.7	14.54	29.07	43.61	58.15	72.69	87.22	101.76	116.30	130.83	.7
.8	14.63	29.26	43.89	58.52	73.15	87.78	102.41	117.04	131.67	.8
.9	14.72	29.44	44.17	58.89	73.61	88.33	103.06	117.78	132.50	.9
16.0	14.81	29.63	44.44	59.26	74.07	88.89	103.70	118.52	133.33	16.0
.1	14.91	29.81	44.72	59.63	74.54	89.44	104.35	119.26	134.17	.1
.2	15.00	30.00	45.00	60.00	75.00	90.00	105.00	120.00	135.00	.2
.3	15.09	30.19	45.28	60.37	75.46	90.56	105.65	120.74	135.83	.3
.4	15.19	30.37	45.56	60.74	75.93	91.11	106.30	121.48	136.67	.4
16.5	15.28	30.56	45.83	61.11	76.39	91.67	106.94	122.22	137.50	16.5
.6	15.37	30.74	46.11	61.48	76.85	92.22	107.59	122.96	138.33	.6
.7	15.46	30.93	46.39	61.85	77.31	92.78	108.24	123.70	139.17	.7
.8	15.56	31.11	46.67	62.22	77.78	93.33	108.89	124.44	140.00	.8
.9	15.65	31.30	46.94	62.59	78.24	93.89	109.54	125.19	140.83	.9
17.0	15.74	31.48	47.22	62.96	78.70	94.44	110.19	125.93	141.67	17.0
.1	15.83	31.67	47.50	63.33	79.17	95.00	110.83	126.67	142.50	.1
.2	15.93	31.85	47.78	63.70	79.63	95.56	111.48	127.41	143.33	.2
.3	16.02	32.04	48.06	64.07	80.09	96.11	112.13	128.15	144.17	.3
.4	16.11	32.22	48.33	64.44	80.56	96.67	112.78	128.89	145.00	.4
17.5	16.20	32.41	48.61	64.81	81.02	97.22	113.43	129.63	145.83	17.5
.6	16.30	32.59	48.89	65.19	81.48	97.78	114.07	130.37	146.67	.6
.7	16.39	32.78	49.17	65.56	81.94	98.33	114.72	131.11	147.50	.7
.8	16.48	32.96	49.44	65.93	82.41	98.89	115.37	131.85	148.33	.8
.9	16.57	33.15	49.72	66.30	82.87	99.44	116.02	132.59	149.17	.9
	1	2	3	4	5	6	7	8	9	

TABLE XXX.—TRIANGULAR PRISMS. CU. YDS. PER 50 FEET.

	WIDTH									
Hght	1	2	3	4	5	6	7	8	9	Hght
18.0	16.67	33.33	50.00	66.67	83.33	100.00	116.67	133.33	150.00	18.0
.1	16.76	33.52	50.28	67.04	83.80	100.56	117.31	134.07	150.83	.1
.2	16.85	33.70	50.56	67.41	84.26	101.11	117.96	134.81	151.67	.2
.3	16.94	33.89	50.83	67.78	84.72	101.67	118.61	135.56	152.50	.3
.4	17.04	34.07	51.11	68.15	85.19	102.22	119.26	136.30	153.33	.4
18.5	17.13	34.26	51.39	68.52	85.65	102.78	119.91	137.04	154.17	18.5
.6	17.22	34.44	51.67	68.89	86.11	103.33	120.56	137.78	155.00	.6
.7	17.31	34.63	51.94	69.26	86.57	103.89	121.20	138.52	155.83	.7
.8	17.41	34.81	52.22	69.63	87.04	104.44	121.85	139.26	156.67	.8
.9	17.50	35.00	52.50	70.00	87.50	105.00	122.50	140.00	157.50	.9
19.0	17.59	35.19	52.78	70.37	87.96	105.56	123.15	140.74	158.33	19.0
.1	17.69	35.37	53.06	70.74	88.43	106.11	123.80	141.48	159.17	.1
.2	17.78	35.56	53.33	71.11	88.89	106.67	124.44	142.22	160.00	.2
.3	17.87	35.74	53.61	71.48	89.35	107.22	125.09	142.96	160.83	.3
.4	17.96	35.93	53.89	71.85	89.81	107.78	125.74	143.70	161.67	.4
19.5	18.06	36.11	54.17	72.22	90.28	108.33	126.39	144.44	162.50	19.5
.6	18.15	36.30	54.44	72.59	90.74	108.89	127.04	145.19	163.33	.6
.7	18.24	36.48	54.72	72.96	91.20	109.44	127.69	145.93	164.17	.7
.8	18.33	36.67	55.00	73.33	91.67	110.00	128.33	146.67	165.00	.8
.9	18.43	36.85	55.28	73.70	92.13	110.56	128.98	147.41	165.83	.9
20.0	18.52	37.04	55.56	74.07	92.59	111.11	129.63	148.15	166.67	20.0
.1	18.61	37.22	55.83	74.44	93.06	111.67	130.28	148.89	167.50	.1
.2	18.70	37.41	56.11	74.81	93.52	112.22	130.93	149.63	168.33	.2
.3	18.80	37.59	56.39	75.19	93.98	112.78	131.57	150.37	169.17	.3
.4	18.89	37.78	56.67	75.56	94.44	113.33	132.22	151.11	170.00	.4
20.5	18.98	37.96	56.94	75.93	94.91	113.89	132.87	151.85	170.83	20.5
.6	19.07	38.15	57.22	76.30	95.37	114.44	133.52	152.59	171.67	.6
.7	19.17	38.33	57.50	76.67	95.83	115.00	134.17	153.33	172.50	.7
.8	19.26	38.52	57.78	77.04	96.30	115.56	134.81	154.07	173.33	.8
.9	19.35	38.70	58.06	77.41	96.76	116.11	135.46	154.81	174.17	.9
21.0	19.44	38.89	58.33	77.78	97.22	116.67	136.11	155.56	175.00	21.0
.1	19.54	39.07	58.61	78.15	97.69	117.22	136.76	156.30	175.83	.1
.2	19.63	39.26	58.89	78.52	98.15	117.78	137.41	157.04	176.67	.2
.3	19.72	39.44	59.17	78.89	98.61	118.33	138.06	157.78	177.50	.3
.4	19.81	39.63	59.44	79.26	99.07	118.89	138.70	158.52	178.33	.4
21.5	19.91	39.81	59.72	79.63	99.54	119.44	139.35	159.26	179.17	21.5
.6	20.00	40.00	60.00	80.00	100.00	120.00	140.00	160.00	180.00	.6
.7	20.09	40.19	60.28	80.37	100.46	120.56	140.65	160.74	180.83	.7
.8	20.19	40.37	60.56	80.74	100.93	121.11	141.30	161.48	181.67	.8
.9	20.28	40.56	60.83	81.11	101.39	121.67	141.94	162.22	182.50	.9
22.0	20.37	40.74	61.11	81.48	101.85	122.22	142.59	162.96	183.33	22.0
.1	20.46	40.93	61.39	81.85	102.31	122.78	143.24	163.70	184.17	.1
.2	20.56	41.11	61.67	82.22	102.78	123.33	143.89	164.44	185.00	.2
.3	20.65	41.30	61.94	82.59	103.24	123.89	144.54	165.19	185.83	.3
.4	20.74	41.48	62.22	82.96	103.70	124.44	145.19	165.93	186.67	.4
22.5	20.83	41.67	62.50	83.33	104.17	125.00	145.83	166.67	187.50	22.5
.6	20.93	41.85	62.78	83.70	104.63	125.56	146.48	167.41	188.33	.6
.7	21.02	42.04	63.06	84.07	105.09	126.11	147.13	168.15	189.17	.7
.8	21.11	42.22	63.33	84.44	105.56	126.67	147.78	168.89	190.00	.8
.9	21.20	42.41	63.61	84.81	106.02	127.22	148.43	169.63	190.83	.9
23.0	21.30	42.59	63.89	85.19	106.48	127.78	149.07	170.37	191.67	23.0
.1	21.39	42.78	64.17	85.56	106.94	128.33	149.72	171.11	192.50	.1
.2	21.48	42.96	64.44	85.93	107.41	128.89	150.37	171.85	193.33	.2
.3	21.57	43.15	64.72	86.30	107.87	129.44	151.02	172.59	194.17	.3
.4	21.67	43.33	65.00	86.67	108.33	130.00	151.67	173.33	195.00	.4
23.5	21.76	43.52	65.28	87.04	108.80	130.56	152.31	174.07	195.83	23.5
.6	21.85	43.70	65.56	87.41	109.26	131.11	152.96	174.81	196.67	.6
.7	21.94	43.89	65.83	87.78	109.72	131.67	153.61	175.56	197.50	.7
.8	22.04	44.07	66.11	88.15	110.19	132.22	154.26	176.30	198.33	.8
.9	22.13	44.26	66.39	88.52	110.65	132.78	154.91	177.04	199.17	.9
	1	2	3	4	5	6	7	8	9	

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
24.0	22.22	44.44	66.67	88.89	111.11	133.33	155.56	177.78	200.00	24.0
.1	22.31	44.63	66.94	89.26	111.57	133.89	156.20	178.52	200.83	.1
.2	22.41	44.81	67.22	89.63	112.04	134.44	156.85	179.26	201.67	.2
.3	22.50	45.00	67.50	90.00	112.50	135.00	157.50	180.00	202.50	.3
.4	22.59	45.19	67.78	90.37	112.96	135.56	158.15	180.74	203.33	.4
24.5	22.69	45.37	68.06	90.74	113.43	136.11	158.80	181.48	204.17	24.5
.6	22.78	45.56	68.33	91.11	113.89	136.67	159.44	182.22	205.00	.6
.7	22.87	45.74	68.61	91.48	114.35	137.22	160.09	182.96	205.83	.7
.8	22.96	45.93	68.89	91.85	114.81	137.78	160.74	183.70	206.67	.8
.9	23.06	46.11	69.17	92.22	115.28	138.33	161.39	184.44	207.50	.9
25.0	23.15	46.30	69.44	92.59	115.74	138.89	162.04	185.19	208.33	25.0
.1	23.24	46.48	69.72	92.96	116.20	139.44	162.69	185.93	209.17	.1
.2	23.33	46.67	70.00	93.33	116.67	140.00	163.33	186.67	210.00	.2
.3	23.43	46.85	70.28	93.70	117.13	140.56	163.98	187.41	210.83	.3
.4	23.52	47.04	70.56	94.07	117.59	141.11	164.63	188.15	211.67	.4
25.5	23.61	47.22	70.83	94.44	118.06	141.67	165.28	188.89	212.50	25.5
.6	23.70	47.41	71.11	94.81	118.52	142.22	165.93	189.63	213.33	.6
.7	23.80	47.59	71.39	95.19	118.98	142.78	166.57	190.37	214.17	.7
.8	23.89	47.78	71.67	95.56	119.44	143.33	167.22	191.11	215.00	.8
.9	23.98	47.96	71.94	95.93	119.91	143.89	167.87	191.85	215.83	.9
26.0	24.07	48.15	72.22	96.30	120.37	144.44	168.52	192.59	216.67	26.0
.1	24.17	48.33	72.50	96.67	120.83	145.00	169.17	193.33	217.50	.1
.2	24.26	48.52	72.78	97.04	121.30	145.56	169.81	194.07	218.33	.2
.3	24.35	48.70	73.06	97.41	121.76	146.11	170.46	194.81	219.17	.3
.4	24.44	48.89	73.33	97.78	122.22	146.67	171.11	195.56	220.00	.4
26.5	24.54	49.07	73.61	98.15	122.69	147.22	171.76	196.30	220.83	26.5
.6	24.63	49.26	73.89	98.52	123.15	147.78	172.41	197.04	221.67	.6
.7	24.72	49.44	74.17	98.89	123.61	148.33	173.06	197.78	222.50	.7
.8	24.81	49.63	74.44	99.26	124.07	148.89	173.70	198.52	223.33	.8
.9	24.91	49.81	74.72	99.63	124.54	149.44	174.35	199.26	224.17	.9
27.0	25.00	50.00	75.00	100.00	125.00	150.00	175.00	200.00	225.00	27.0
.1	25.09	50.19	75.28	100.37	125.46	150.56	175.65	200.74	225.83	.1
.2	25.19	50.37	75.56	100.74	125.93	151.11	176.30	201.48	226.67	.2
.3	25.28	50.56	75.83	101.11	126.39	151.67	176.94	202.22	227.50	.3
.4	25.37	50.74	76.11	101.48	126.85	152.22	177.59	202.96	228.33	.4
27.5	25.46	50.93	76.39	101.85	127.31	152.78	178.24	203.70	229.17	27.5
.6	25.56	51.11	76.67	102.22	127.78	153.33	178.89	204.44	230.00	.6
.7	25.65	51.30	76.94	102.59	128.24	153.89	179.54	205.19	230.83	.7
.8	25.74	51.48	77.22	102.96	128.70	154.44	180.19	205.93	231.67	.8
.9	25.83	51.67	77.50	103.33	129.17	155.00	180.83	206.67	232.50	.9
28.0	25.93	51.85	77.78	103.70	129.63	155.56	181.48	207.41	233.33	28.0
.1	26.02	52.04	78.06	104.07	130.09	156.11	182.13	208.15	234.17	.1
.2	26.11	52.22	78.33	104.44	130.56	156.67	182.78	208.89	235.00	.2
.3	26.20	52.41	78.61	104.81	131.02	157.22	183.43	209.63	235.83	.3
.4	26.30	52.59	78.89	105.19	131.48	157.78	184.07	210.37	236.67	.4
28.5	26.39	52.78	79.17	105.56	131.94	158.33	184.72	211.11	237.50	28.5
.6	26.48	52.96	79.44	105.93	132.41	158.89	185.37	211.85	238.33	.6
.7	26.57	53.15	79.72	106.30	132.87	159.44	186.02	212.59	239.17	.7
.8	26.67	53.33	80.00	106.67	133.33	160.00	186.67	213.33	240.00	.8
.9	26.76	53.52	80.28	107.04	133.80	160.56	187.31	214.07	240.83	.9
29.0	26.85	53.70	80.56	107.41	134.26	161.11	187.96	214.81	241.67	29.0
.1	26.94	53.89	80.83	107.78	134.72	161.67	188.61	215.56	242.50	.1
.2	27.04	54.07	81.11	108.15	135.19	162.22	189.26	216.30	243.33	.2
.3	27.13	54.26	81.39	108.52	135.65	162.78	189.91	217.04	244.17	.3
.4	27.22	54.44	81.67	108.89	136.11	163.33	190.56	217.78	245.00	.4
29.5	27.31	54.63	81.94	109.26	136.57	163.89	191.20	218.52	245.83	29.5
.6	27.41	54.81	82.22	109.63	137.04	164.44	191.85	219.26	246.67	.6
.7	27.50	55.00	82.50	110.00	137.50	165.00	192.50	220.00	247.50	.7
.8	27.59	55.19	82.78	110.37	137.96	165.56	193.15	220.74	248.33	.8
.9	27.69	55.37	83.06	110.74	138.43	166.11	193.80	221.48	249.17	.9
	1	2	3	4	5	6	7	8	9	

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
30.0	27.78	55.56	83.33	111.11	138.89	166.67	194.44	222.22	250.00	30.0
.1	27.87	55.74	83.61	111.48	139.35	167.22	195.09	222.96	250.83	.1
.2	27.96	55.93	83.89	111.85	139.81	167.78	195.74	223.70	251.67	.2
.3	28.06	56.11	84.17	112.22	140.28	168.33	196.39	224.44	252.50	.3
.4	28.15	56.30	84.44	112.59	140.74	168.89	197.04	225.19	253.33	.4
30.5	28.24	56.48	84.72	112.96	141.20	169.44	197.69	225.93	254.17	30.5
.6	28.33	56.67	85.00	113.33	141.67	170.00	198.33	226.67	255.00	.6
.7	28.43	56.85	85.28	113.70	142.13	170.56	198.98	227.41	255.83	.7
.8	28.52	57.04	85.56	114.07	142.59	171.11	199.63	228.15	256.67	.8
.9	28.61	57.22	85.83	114.44	143.06	171.67	200.28	228.89	257.50	.9
31.0	28.70	57.41	86.11	114.81	143.52	172.22	200.93	229.63	258.33	31.0
.1	28.80	57.59	86.39	115.19	143.98	172.78	201.57	230.37	259.17	.1
.2	28.89	57.78	86.67	115.56	144.44	173.33	202.22	231.11	260.00	.2
.3	28.98	57.96	86.94	115.93	144.91	173.89	202.87	231.85	260.83	.3
.4	29.07	58.15	87.22	116.30	145.37	174.44	203.52	232.59	261.67	.4
31.5	29.17	58.33	87.50	116.67	145.83	175.00	204.17	233.33	262.50	31.5
.6	29.26	58.52	87.78	117.04	146.30	175.56	204.81	234.07	263.33	.6
.7	29.35	58.70	88.06	117.41	146.76	176.11	205.46	234.81	264.17	.7
.8	29.44	58.89	88.33	117.78	147.22	176.67	206.11	235.56	265.00	.8
.9	29.54	59.07	88.61	118.15	147.69	177.22	206.76	236.30	265.83	.9
32.0	29.63	59.26	88.89	118.52	148.15	177.78	207.41	237.04	266.67	32.0
.1	29.72	59.44	89.17	118.89	148.61	178.33	208.06	237.78	267.50	.1
.2	29.81	59.63	89.44	119.26	149.07	178.89	208.70	238.52	268.33	.2
.3	29.91	59.81	89.72	119.63	149.54	179.44	209.35	239.26	269.17	.3
.4	30.00	60.00	90.00	120.00	150.00	180.00	210.00	240.00	270.00	.4
32.5	30.09	60.19	90.28	120.37	150.46	180.56	210.65	240.74	270.83	32.5
.6	30.19	60.37	90.56	120.74	150.93	181.11	211.30	241.48	271.67	.6
.7	30.28	60.56	90.83	121.11	151.39	181.67	211.94	242.22	272.50	.7
.8	30.37	60.74	91.11	121.48	151.85	182.22	212.59	242.96	273.33	.8
.9	30.46	60.93	91.39	121.85	152.31	182.78	213.24	243.70	274.17	.9
33.0	30.56	61.11	91.67	122.22	152.78	183.33	213.89	244.44	275.00	33.0
.1	30.65	61.30	91.94	122.59	153.24	183.89	214.54	245.19	275.83	.1
.2	30.74	61.48	92.22	122.96	153.70	184.44	215.19	245.93	276.67	.2
.3	30.83	61.67	92.50	123.33	154.17	185.00	215.83	246.67	277.50	.3
.4	30.93	61.85	92.78	123.70	154.63	185.56	216.48	247.41	278.33	.4
33.5	31.02	62.04	93.06	124.07	155.09	186.11	217.13	248.15	279.17	33.5
.6	31.11	62.22	93.33	124.44	155.56	186.67	217.78	248.89	280.00	.6
.7	31.20	62.41	93.61	124.81	156.02	187.22	218.43	249.63	280.83	.7
.8	31.30	62.59	93.89	125.19	156.48	187.78	219.07	250.37	281.67	.8
.9	31.39	62.78	94.17	125.56	156.94	188.33	219.72	251.11	282.50	.9
34.0	31.48	62.96	94.44	125.93	157.41	188.89	220.37	251.85	283.33	34.0
.1	31.57	63.15	94.72	126.30	157.87	189.44	221.02	252.59	284.17	.1
.2	31.67	63.33	95.00	126.67	158.33	190.00	221.67	253.33	285.00	.2
.3	31.76	63.52	95.28	127.04	158.80	190.56	222.31	254.07	285.83	.3
.4	31.85	63.70	95.56	127.41	159.26	191.11	222.96	254.81	286.67	.4
34.5	31.94	63.89	95.83	127.78	159.72	191.67	223.61	255.56	287.50	34.5
.6	32.04	64.07	96.11	128.15	160.19	192.22	224.26	256.30	288.33	.6
.7	32.13	64.26	96.39	128.52	160.65	192.78	224.91	257.04	289.17	.7
.8	32.22	64.44	96.67	128.89	161.11	193.33	225.56	257.78	290.00	.8
.9	32.31	64.63	96.94	129.26	161.57	193.89	226.20	258.52	290.83	.9
35.0	32.41	64.81	97.22	129.63	162.04	194.44	226.85	259.26	291.67	35.0
.1	32.50	65.00	97.50	130.00	162.50	195.00	227.50	260.00	292.50	.1
.2	32.59	65.19	97.78	130.37	162.96	195.56	228.15	260.74	293.33	.2
.3	32.69	65.37	98.06	130.74	163.43	196.11	228.80	261.48	294.17	.3
.4	32.78	65.56	98.33	131.11	163.89	196.67	229.44	262.22	295.00	.4
35.5	32.87	65.74	98.61	131.48	164.35	197.22	230.09	262.96	295.83	35.5
.6	32.96	65.93	98.89	131.85	164.81	197.78	230.74	263.70	296.67	.6
.7	33.06	66.11	99.17	132.22	165.28	198.33	231.39	264.44	297.50	.7
.8	33.15	66.30	99.44	132.59	165.74	198.89	232.04	265.19	298.33	.8
.9	33.24	66.48	99.72	132.96	166.20	199.44	232.69	265.93	299.17	.9
	1	2	3	4	5	6	7	8	9	

TABLE XXX.—TRIANGULAR PRISMS. CU. YDS. PER 50 FEET.

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
36.0	33.33	66.67	100.00	133.33	166.67	200.00	233.33	266.67	300.00	36.0
.1	33.43	66.85	100.28	133.70	167.13	200.56	233.98	267.41	300.83	.1
.2	33.52	67.04	100.56	134.07	167.59	201.11	234.63	268.15	301.67	.2
.3	33.61	67.22	100.83	134.44	168.06	201.67	235.28	268.89	302.50	.3
.4	33.70	67.41	101.11	134.81	168.52	202.22	235.93	269.63	303.33	.4
36.5	33.80	67.59	101.39	135.19	168.98	202.78	236.57	270.37	304.17	36.5
.6	33.89	67.78	101.67	135.56	169.44	203.33	237.22	271.11	305.00	.6
.7	33.98	67.96	101.94	135.93	169.91	203.89	237.87	271.85	305.83	.7
.8	34.07	68.15	102.22	136.30	170.37	204.44	238.52	272.59	306.67	.8
.9	34.17	68.33	102.50	136.67	170.83	205.00	239.17	273.33	307.50	.9
37.0	34.26	68.52	102.78	137.04	171.30	205.56	239.81	274.07	308.33	37.0
.1	34.35	68.70	103.06	137.41	171.76	206.11	240.46	274.81	309.17	.1
.2	34.44	68.89	103.33	137.78	172.22	206.67	241.11	275.56	310.00	.2
.3	34.54	69.07	103.61	138.15	172.69	207.22	241.76	276.30	310.83	.3
.4	34.63	69.26	103.89	138.52	173.15	207.78	242.41	277.04	311.67	.4
37.5	34.72	69.44	104.17	138.89	173.61	208.33	243.06	277.78	312.50	37.5
.6	34.81	69.63	104.44	139.26	174.07	208.89	243.70	278.52	313.33	.6
.7	34.91	69.81	104.72	139.63	174.54	209.44	244.35	279.26	314.17	.7
.8	35.00	70.00	105.00	140.00	175.00	210.00	245.00	280.00	315.00	.8
.9	35.09	70.19	105.28	140.37	175.46	210.56	245.65	280.74	315.83	.9
38.0	35.19	70.37	105.56	140.74	175.93	211.11	246.30	281.48	316.67	38.0
.1	35.28	70.56	105.83	141.11	176.39	211.67	246.94	282.22	317.50	.1
.2	35.37	70.74	106.11	141.48	176.85	212.22	247.59	282.96	318.33	.2
.3	35.46	70.93	106.39	141.85	177.31	212.78	248.24	283.70	319.17	.3
.4	35.56	71.11	106.67	142.22	177.78	213.33	248.89	284.44	320.00	.4
38.5	35.65	71.30	106.94	142.59	178.24	213.89	249.54	285.19	320.83	38.5
.6	35.74	71.48	107.22	142.96	178.70	214.44	250.19	285.93	321.67	.6
.7	35.83	71.67	107.50	143.33	179.17	215.00	250.83	286.67	322.50	.7
.8	35.93	71.85	107.78	143.70	179.63	215.56	251.48	287.41	323.33	.8
.9	36.02	72.04	108.06	144.07	180.09	216.11	252.13	288.15	324.17	.9
39.0	36.11	72.22	108.33	144.44	180.56	216.67	252.78	288.89	325.00	39.0
.1	36.20	72.41	108.61	144.81	181.02	217.22	253.43	289.63	325.83	.1
.2	36.30	72.59	108.89	145.19	181.48	217.78	254.07	290.37	326.67	.2
.3	36.39	72.78	109.17	145.56	181.94	218.33	254.72	291.11	327.50	.3
.4	36.48	72.96	109.44	145.93	182.41	218.89	255.37	291.85	328.33	.4
39.5	36.57	73.15	109.72	146.30	182.87	219.44	256.02	292.59	329.17	39.5
.6	36.67	73.33	110.00	146.67	183.33	220.00	256.67	293.33	330.00	.6
.7	36.76	73.52	110.28	147.04	183.80	220.56	257.31	294.07	330.83	.7
.8	36.85	73.70	110.56	147.41	184.26	221.11	257.96	294.81	331.67	.8
.9	36.94	73.89	110.83	147.78	184.72	221.67	258.61	295.56	332.50	.9
40.0	37.04	74.07	111.11	148.15	185.19	222.22	259.26	296.30	333.33	40.0
.1	37.13	74.26	111.39	148.52	185.65	222.78	259.91	297.04	334.17	.1
.2	37.22	74.44	111.67	148.89	186.11	223.33	260.56	297.78	335.00	.2
.3	37.31	74.63	111.94	149.26	186.57	223.89	261.20	298.52	335.83	.3
.4	37.41	74.81	112.22	149.63	187.04	224.44	261.85	299.26	336.67	.4
40.5	37.50	75.00	112.50	150.00	187.50	225.00	262.50	300.00	337.50	40.5
.6	37.59	75.19	112.78	150.37	187.96	225.56	263.15	300.74	338.33	.6
.7	37.69	75.37	113.06	150.74	188.43	226.11	263.80	301.48	339.17	.7
.8	37.78	75.56	113.33	151.11	188.89	226.67	264.44	302.22	340.00	.8
.9	37.87	75.74	113.61	151.48	189.35	227.22	265.09	302.96	340.83	.9
41.0	37.96	75.93	113.89	151.85	189.81	227.78	265.74	303.70	341.67	41.0
.1	38.06	76.11	114.17	152.22	190.28	228.33	266.39	304.44	342.50	.1
.2	38.15	76.30	114.44	152.59	190.74	228.89	267.04	305.19	343.33	.2
.3	38.24	76.48	114.72	152.96	191.20	229.44	267.69	305.93	344.17	.3
.4	38.33	76.67	115.00	153.33	191.67	230.00	268.33	306.67	345.00	.4
41.5	38.43	76.85	115.28	153.70	192.13	230.56	268.98	307.41	345.83	41.5
.6	38.52	77.04	115.56	154.07	192.59	231.11	269.63	308.15	346.67	.6
.7	38.61	77.22	115.83	154.44	193.06	231.67	270.28	308.89	347.50	.7
.8	38.70	77.41	116.11	154.81	193.52	232.22	270.93	309.63	348.33	.8
.9	38.80	77.59	116.39	155.19	193.98	232.78	271.57	310.37	349.17	.9
	1	2	3	4	5	6	7	8	9	

TABLE XXX.—TRIANGULAR PRISMS. CU. YDS. PER 50 FEET.

Hght	WIDTH 1	2	3	4	5	6	7	8	9	Hght
42.0	38.89	77.78	116.67	155.56	194.44	233.33	272.22	311.11	350.00	42.0
.1	38.98	77.96	116.94	155.93	194.91	233.89	272.87	311.85	350.83	.1
.2	39.07	78.15	117.22	156.30	195.37	234.44	273.52	312.59	351.67	.2
.3	39.17	78.33	117.50	156.67	195.83	235.00	274.17	313.33	352.50	.3
.4	39.26	78.52	117.78	157.04	196.30	235.56	274.81	314.07	353.33	.4
42.5	39.35	78.70	118.06	157.41	196.76	236.11	275.46	314.81	354.17	42.5
.6	39.44	78.89	118.33	157.78	197.22	236.67	276.11	315.56	355.00	.6
.7	39.54	79.07	118.61	158.15	197.69	237.22	276.76	316.30	355.83	.7
.8	39.63	79.26	118.89	158.52	198.15	237.78	277.41	317.04	356.67	.8
.9	39.72	79.44	119.17	158.89	198.61	238.33	278.06	317.78	357.50	.9
43.0	39.81	79.63	119.44	159.26	199.07	238.89	278.70	318.52	358.33	43.0
.1	39.91	79.81	119.72	159.63	199.54	239.44	279.35	319.26	359.17	.1
.2	40.00	80.00	120.00	160.00	200.00	240.00	280.00	320.00	360.00	.2
.3	40.09	80.19	120.28	160.37	200.46	240.56	280.65	320.74	360.83	.3
.4	40.19	80.37	120.56	160.74	200.93	241.11	281.30	321.48	361.67	.4
43.5	40.28	80.56	120.83	161.11	201.39	241.67	281.94	322.22	362.50	43.5
.6	40.37	80.74	121.11	161.48	201.85	242.22	282.59	322.96	363.33	.6
.7	40.46	80.93	121.39	161.85	202.31	242.78	283.24	323.70	364.17	.7
.8	40.56	81.11	121.67	162.22	202.78	243.33	283.89	324.44	365.00	.8
.9	40.65	81.30	121.94	162.59	203.24	243.89	284.54	325.19	365.83	.9
44.0	40.74	81.48	122.22	162.96	203.70	244.44	285.19	325.93	366.67	44.0
.1	40.83	81.67	122.50	163.33	204.17	245.00	285.83	326.67	367.50	.1
.2	40.93	81.85	122.78	163.70	204.63	245.56	286.48	327.41	368.33	.2
.3	41.02	82.04	123.06	164.07	205.09	246.11	287.13	328.15	369.17	.3
.4	41.11	82.22	123.33	164.44	205.56	246.67	287.78	328.89	370.00	.4
44.5	41.20	82.41	123.61	164.81	206.02	247.22	288.43	329.63	370.83	44.5
.6	41.30	82.59	123.89	165.19	206.48	247.78	289.07	330.37	371.67	.6
.7	41.39	82.78	124.17	165.56	206.94	248.33	289.72	331.11	372.50	.7
.8	41.48	82.96	124.44	165.93	207.41	248.89	290.37	331.85	373.33	.8
.9	41.57	83.15	124.72	166.30	207.87	249.44	291.02	332.59	374.17	.9
45.0	41.67	83.33	125.00	166.67	208.33	250.00	291.67	333.33	375.00	45.0
.1	41.76	83.52	125.28	167.04	208.80	250.56	292.31	334.07	375.83	.1
.2	41.85	83.70	125.56	167.41	209.26	251.11	292.96	334.81	376.67	.2
.3	41.94	83.89	125.83	167.78	209.72	251.67	293.61	335.56	377.50	.3
.4	42.04	84.07	126.11	168.15	210.19	252.22	294.26	336.30	378.33	.4
45.5	42.13	84.26	126.39	168.52	210.65	252.78	294.91	337.04	379.17	45.5
.6	42.22	84.44	126.67	168.89	211.11	253.33	295.56	337.78	380.00	.6
.7	42.31	84.63	126.94	169.26	211.57	253.89	296.20	338.52	380.83	.7
.8	42.41	84.81	127.22	169.63	212.04	254.44	296.85	339.26	381.67	.8
.9	42.50	85.00	127.50	170.00	212.50	255.00	297.50	340.00	382.50	.9
46.0	42.59	85.19	127.78	170.37	212.96	255.56	298.15	340.74	383.33	46.0
.1	42.69	85.37	128.06	170.74	213.43	256.11	298.80	341.48	384.17	.1
.2	42.78	85.56	128.33	171.11	213.89	256.67	299.44	342.22	385.00	.2
.3	42.87	85.74	128.61	171.48	214.35	257.22	300.09	342.96	385.83	.3
.4	42.96	85.93	128.89	171.85	214.81	257.78	300.74	343.70	386.67	.4
46.5	43.06	86.11	129.17	172.22	215.28	258.33	301.39	344.44	387.50	46.5
.6	43.15	86.30	129.44	172.59	215.74	258.89	302.04	345.19	388.33	.6
.7	43.24	86.48	129.72	172.96	216.20	259.44	302.69	345.93	389.17	.7
.8	43.33	86.67	130.00	173.33	216.67	260.00	303.33	346.67	390.00	.8
.9	43.43	86.85	130.28	173.70	217.13	260.56	303.98	347.41	390.83	.9
47.0	43.52	87.04	130.56	174.07	217.59	261.11	304.63	348.15	391.67	47.0
.1	43.61	87.22	130.83	174.44	218.06	261.67	305.28	348.89	392.50	.1
.2	43.70	87.41	131.11	174.81	218.52	262.22	305.93	349.63	393.33	.2
.3	43.80	87.59	131.39	175.19	218.98	262.78	306.57	350.37	394.17	.3
.4	43.89	87.78	131.67	175.56	219.44	263.33	307.22	351.11	395.00	.4
47.5	43.98	87.96	131.94	175.93	219.91	263.89	307.87	351.85	395.83	47.5
.6	44.07	88.15	132.22	176.30	220.37	264.44	308.52	352.59	396.67	.6
.7	44.17	88.33	132.50	176.67	220.83	265.00	309.17	353.33	397.50	.7
.8	44.26	88.52	132.78	177.04	221.30	265.56	309.81	354.07	398.33	.8
.9	44.35	88.70	133.06	177.41	221.76	266.11	310.46	354.81	399.17	.9
	1	2	3	4	5	6	7	8	9	

c_0-c_1	1	2	3	4	5	6	7	8	9	c_0
D_0-D_1										D_0
0.1	.03	.06	.09	.12	.15	.19	.22	.25	.28	
.2	.06	.12	.19	.25	.31	.37	.43	.49	.56	
.3	.09	.19	.28	.37	.46	.56	.65	.74	.83	
.4	.12	.25	.37	.49	.62	.74	.86	.99	1.11	
0.5	.15	.31	.46	.62	.77	.93	1.08	1.23	1.39	
.6	.19	.37	.56	.74	.93	1.11	1.30	1.48	1.67	
.7	.22	.43	.65	.86	1.08	1.30	1.51	1.73	1.94	
.8	.25	.49	.74	.99	1.23	1.48	1.73	1.98	2.22	
.9	.28	.56	.83	1.11	1.39	1.67	1.94	2.22	2.50	
1.0	.31	.62	.93	1.23	1.54	1.85	2.16	2.47	2.78	
.1	.34	.68	1.02	1.36	1.70	2.04	2.38	2.72	3.06	
.2	.37	.74	1.11	1.48	1.85	2.22	2.59	2.96	3.33	
.3	.40	.80	1.20	1.60	2.01	2.41	2.81	3.21	3.61	
.4	.43	.86	1.30	1.73	2.16	2.59	3.02	3.46	3.89	
1.5	.46	.93	1.39	1.85	2.31	2.78	3.24	3.70	4.17	
.6	.49	.99	1.48	1.98	2.47	2.96	3.46	3.95	4.44	
.7	.52	1.05	1.57	2.10	2.62	3.15	3.67	4.20	4.72	
.8	.56	1.11	1.67	2.22	2.78	3.33	3.89	4.44	5.00	
.9	.59	1.17	1.76	2.35	2.93	3.52	4.10	4.69	5.28	
2.0	.62	1.23	1.85	2.47	3.09	3.70	4.32	4.94	5.56	2
.1	.65	1.30	1.94	2.59	3.24	3.89	4.54	5.19	5.83	
.2	.68	1.36	2.04	2.72	3.40	4.07	4.75	5.43	6.11	
.3	.71	1.42	2.13	2.84	3.55	4.26	4.97	5.68	6.39	
.4	.74	1.48	2.22	2.96	3.70	4.44	5.19	5.93	6.67	
2.5	.77	1.54	2.31	3.09	3.86	4.63	5.40	6.17	6.94	2
.6	.80	1.60	2.41	3.21	4.01	4.81	5.62	6.42	7.22	
.7	.83	1.67	2.50	3.33	4.17	5.00	5.83	6.67	7.50	
.8	.86	1.73	2.59	3.46	4.32	5.19	6.05	6.91	7.78	
.9	.90	1.79	2.69	3.58	4.48	5.37	6.27	7.16	8.06	
3.0	.93	1.85	2.78	3.70	4.63	5.56	6.48	7.41	8.33	3
.1	.96	1.91	2.87	3.83	4.78	5.74	6.70	7.65	8.61	
.2	.99	1.98	2.96	3.95	4.94	5.93	6.91	7.90	8.89	
.3	1.02	2.04	3.06	4.07	5.09	6.11	7.13	8.15	9.17	
.4	1.05	2.10	3.15	4.20	5.25	6.30	7.35	8.40	9.44	
3.5	1.08	2.16	3.24	4.32	5.40	6.48	7.56	8.64	9.72	3
.6	1.11	2.22	3.33	4.44	5.56	6.67	7.78	8.89	10.00	
.7	1.14	2.28	3.43	4.57	5.71	6.85	7.99	9.14	10.28	
.8	1.17	2.35	3.52	4.69	5.86	7.04	8.21	9.38	10.56	
.9	1.20	2.41	3.61	4.81	6.02	7.22	8.43	9.63	10.83	
4.0	1.23	2.47	3.70	4.94	6.17	7.41	8.64	9.88	11.11	4
.1	1.27	2.53	3.80	5.06	6.33	7.59	8.86	10.12	11.39	
.2	1.30	2.59	3.89	5.19	6.48	7.78	9.07	10.37	11.67	
.3	1.33	2.65	3.98	5.31	6.64	7.96	9.29	10.62	11.94	
.4	1.36	2.72	4.07	5.43	6.79	8.15	9.51	10.86	12.22	
4.5	1.39	2.78	4.17	5.56	6.94	8.33	9.72	11.11	12.50	4
.6	1.42	2.84	4.26	5.68	7.10	8.52	9.94	11.36	12.78	
.7	1.45	2.90	4.35	5.80	7.25	8.70	10.15	11.60	13.06	
.8	1.48	2.96	4.44	5.93	7.41	8.89	10.37	11.85	13.33	
.9	1.51	3.02	4.54	6.05	7.56	9.07	10.59	12.10	13.61	
5.0	1.54	3.09	4.63	6.17	7.72	9.26	10.80	12.35	13.89	5
.1	1.57	3.15	4.72	6.30	7.87	9.44	11.02	12.59	14.17	
.2	1.60	3.21	4.81	6.42	8.02	9.63	11.23	12.84	14.44	
.3	1.64	3.27	4.91	6.54	8.18	9.81	11.45	13.09	14.72	
.4	1.67	3.33	5.00	6.67	8.33	10.00	11.67	13.33	15.00	
5.5	1.70	3.40	5.09	6.79	8.49	10.19	11.88	13.58	15.28	5
.6	1.73	3.46	5.19	6.91	8.64	10.37	12.10	13.83	15.56	
.7	1.76	3.52	5.28	7.04	8.80	10.56	12.31	14.07	15.83	
.8	1.79	3.58	5.37	7.16	8.95	10.74	12.53	14.32	16.11	
.9	1.82	3.64	5.46	7.28	9.10	10.93	12.75	14.57	16.39	
	1	2	3	4	5	6	7	8	9	

TABLE XXXI.—PRISMOIDAL CORRECTION. CU. YDS. PER 100 FT.

c_0-c_1	1	2	3	4	5	6	7	8	9	c_0-c_1
D_0-D_1										D_0-D_1
6.0	1.85	3.70	5.56	7.41	9.26	11.11	12.96	14.81	16.67	6.0
.1	1.88	3.77	5.65	7.53	9.41	11.30	13.18	15.06	16.94	.1
.2	1.91	3.83	5.74	7.65	9.57	11.48	13.40	15.31	17.22	.2
.3	1.94	3.89	5.83	7.78	9.72	11.67	13.61	15.56	17.50	.3
.4	1.98	3.95	5.93	7.90	9.88	11.85	13.83	15.80	17.78	.4
6.5	2.01	4.01	6.02	8.02	10.03	12.04	14.04	16.05	18.06	6.5
.6	2.04	4.07	6.11	8.15	10.19	12.22	14.26	16.30	18.33	.6
.7	2.07	4.14	6.20	8.27	10.34	12.41	14.48	16.54	18.61	.7
.8	2.10	4.20	6.30	8.40	10.49	12.59	14.69	16.79	18.89	.8
.9	2.13	4.26	6.39	8.52	10.65	12.78	14.91	17.04	19.17	.9
7.0	2.16	4.32	6.48	8.64	10.80	12.96	15.12	17.28	19.44	7.0
.1	2.19	4.38	6.57	8.77	10.96	13.15	15.34	17.53	19.72	.1
.2	2.22	4.44	6.67	8.89	11.11	13.33	15.56	17.78	20.00	.2
.3	2.25	4.51	6.76	9.01	11.27	13.52	15.77	18.02	20.28	.3
.4	2.28	4.57	6.85	9.14	11.42	13.70	15.99	18.27	20.56	.4
7.5	2.31	4.63	6.94	9.26	11.57	13.89	16.20	18.52	20.83	7.5
.6	2.35	4.69	7.04	9.38	11.73	14.07	16.42	18.77	21.11	.6
.7	2.38	4.75	7.13	9.51	11.88	14.26	16.64	19.01	21.39	.7
.8	2.41	4.81	7.22	9.63	12.04	14.44	16.85	19.26	21.67	.8
.9	2.44	4.88	7.31	9.75	12.19	14.63	17.07	19.51	21.94	.9
8.0	2.47	4.94	7.41	9.88	12.35	14.81	17.28	19.75	22.22	8.0
.1	2.50	5.00	7.50	10.00	12.50	15.00	17.50	20.00	22.50	.1
.2	2.53	5.06	7.59	10.12	12.65	15.19	17.72	20.25	22.78	.2
.3	2.56	5.12	7.69	10.25	12.81	15.37	17.93	20.49	23.06	.3
.4	2.59	5.19	7.78	10.37	12.96	15.56	18.15	20.74	23.33	.4
8.5	2.62	5.25	7.87	10.49	13.12	15.74	18.36	20.99	23.61	8.5
.6	2.65	5.31	7.96	10.62	13.27	15.93	18.58	21.23	23.89	.6
.7	2.69	5.37	8.06	10.74	13.43	16.11	18.80	21.48	24.17	.7
.8	2.72	5.43	8.15	10.86	13.58	16.30	19.01	21.73	24.44	.8
.9	2.75	5.49	8.24	10.99	13.73	16.48	19.23	21.98	24.72	.9
9.0	2.78	5.56	8.33	11.11	13.89	16.67	19.44	22.22	25.00	9.0
.1	2.81	5.62	8.43	11.23	14.04	16.85	19.66	22.47	25.28	.1
.2	2.84	5.68	8.52	11.36	14.20	17.04	19.88	22.72	25.56	.2
.3	2.87	5.74	8.61	11.48	14.35	17.22	20.09	22.96	25.83	.3
.4	2.90	5.80	8.70	11.60	14.51	17.41	20.31	23.21	26.11	.4
9.5	2.93	5.86	8.80	11.73	14.66	17.59	20.52	23.46	26.39	9.5
.6	2.96	5.93	8.89	11.85	14.81	17.78	20.74	23.70	26.67	.6
.7	2.99	5.99	8.98	11.98	14.97	17.96	20.96	23.95	26.94	.7
.8	3.02	6.05	9.07	12.10	15.12	18.15	21.17	24.20	27.22	.8
.9	3.06	6.11	9.17	12.22	15.28	18.33	21.39	24.44	27.50	.9
10.0	3.09	6.17	9.26	12.35	15.43	18.52	21.60	24.69	27.78	10.0
.1	3.12	6.23	9.35	12.47	15.59	18.70	21.82	24.94	28.06	.1
.2	3.15	6.30	9.44	12.59	15.74	18.89	22.04	25.19	28.33	.2
.3	3.18	6.36	9.54	12.72	15.90	19.07	22.25	25.43	28.61	.3
.4	3.21	6.42	9.63	12.84	16.05	19.26	22.47	25.68	28.89	.4
10.5	3.24	6.48	9.72	12.96	16.20	19.44	22.69	25.93	29.17	10.5
.6	3.27	6.54	9.81	13.09	16.36	19.63	22.90	26.17	29.44	.6
.7	3.30	6.60	9.91	13.21	16.51	19.81	23.12	26.42	29.72	.7
.8	3.33	6.67	10.00	13.33	16.67	20.00	23.33	26.67	30.00	.8
.9	3.36	6.73	10.09	13.46	16.82	20.19	23.55	26.91	30.28	.9
11.0	3.40	6.79	10.19	13.58	16.98	20.37	23.77	27.16	30.56	11.0
.1	3.43	6.85	10.28	13.70	17.13	20.56	23.98	27.41	30.83	.1
.2	3.46	6.91	10.37	13.83	17.28	20.74	24.20	27.65	31.11	.2
.3	3.49	6.98	10.46	13.95	17.44	20.93	24.41	27.90	31.39	.3
.4	3.52	7.04	10.56	14.07	17.59	21.11	24.63	28.15	31.67	.4
11.5	3.55	7.10	10.65	14.20	17.75	21.30	24.85	28.40	31.94	11.5
.6	3.58	7.16	10.74	14.32	17.90	21.48	25.06	28.64	32.22	.6
.7	3.61	7.22	10.83	14.44	18.06	21.67	25.28	28.89	32.50	.7
.8	3.64	7.28	10.93	14.57	18.21	21.85	25.49	29.14	32.78	.8
.9	3.67	7.35	11.02	14.69	18.36	22.04	25.71	29.38	33.06	.9
	1	2	3	4	5	6	7	8	9	

c_0-c_1	1	2	3	4	5	6	7	8	9	c_0-c_1
D_0-D_1										D_0-D_1
12.0	3.70	7.41	11.11	14.81	18.52	22.22	25.93	29.63	33.33	12.0
.1	3.73	7.47	11.20	14.94	18.67	22.41	26.14	29.88	33.61	.1
.2	3.77	7.53	11.30	15.06	18.83	22.59	26.36	30.12	33.89	.2
.3	3.80	7.59	11.39	15.19	18.98	22.78	26.57	30.37	34.17	.3
.4	3.83	7.65	11.48	15.31	19.14	22.96	26.79	30.62	34.44	.4
12.5	3.86	7.72	11.57	15.43	19.29	23.15	27.01	30.86	34.72	12.5
.6	3.89	7.78	11.67	15.56	19.44	23.33	27.22	31.11	35.00	.6
.7	3.92	7.84	11.76	15.68	19.60	23.52	27.44	31.36	35.28	.7
.8	3.95	7.90	11.85	15.80	19.75	23.70	27.65	31.60	35.56	.8
.9	3.98	7.96	11.94	15.93	19.91	23.89	27.87	31.85	35.83	.9
13.0	4.01	8.02	12.04	16.05	20.06	24.07	28.09	32.10	36.11	13.0
.1	4.04	8.09	12.13	16.17	20.22	24.26	28.30	32.35	36.39	.1
.2	4.07	8.15	12.22	16.30	20.37	24.44	28.52	32.59	36.67	.2
.3	4.11	8.21	12.31	16.42	20.52	24.63	28.73	32.84	36.94	.3
.4	4.14	8.27	12.41	16.54	20.68	24.81	28.95	33.09	37.22	.4
13.5	4.17	8.33	12.50	16.67	20.83	25.00	29.17	33.33	37.50	13.5
.6	4.20	8.40	12.59	16.79	20.99	25.19	29.38	33.58	37.78	.6
.7	4.23	8.46	12.69	16.91	21.14	25.37	29.60	33.83	38.06	.7
.8	4.26	8.52	12.78	17.04	21.30	25.56	29.81	34.07	38.33	.8
.9	4.29	8.58	12.87	17.16	21.45	25.74	30.03	34.32	38.61	.9
14.0	4.32	8.64	12.96	17.28	21.60	25.93	30.25	34.57	38.89	14.0
.1	4.35	8.70	13.06	17.41	21.76	26.11	30.46	34.81	39.17	.1
.2	4.38	8.77	13.15	17.53	21.91	26.30	30.68	35.06	39.44	.2
.3	4.41	8.83	13.24	17.65	22.07	26.48	30.90	35.31	39.72	.3
.4	4.44	8.89	13.33	17.78	22.22	26.67	31.11	35.56	40.00	.4
14.5	4.48	8.95	13.43	17.90	22.38	26.85	31.33	35.80	40.28	14.5
.6	4.51	9.01	13.52	18.02	22.53	27.04	31.54	36.05	40.56	.6
.7	4.54	9.07	13.61	18.15	22.69	27.22	31.76	36.30	40.83	.7
.8	4.57	9.14	13.70	18.27	22.84	27.41	31.98	36.54	41.11	.8
.9	4.60	9.20	13.80	18.40	22.99	27.59	32.19	36.79	41.39	.9
15.0	4.63	9.26	13.89	18.52	23.15	27.78	32.41	37.04	41.67	15.0
.1	4.66	9.32	13.98	18.64	23.30	27.96	32.62	37.28	41.94	.1
.2	4.69	9.38	14.07	18.77	23.46	28.15	32.84	37.53	42.22	.2
.3	4.72	9.44	14.17	18.89	23.61	28.33	33.06	37.78	42.50	.3
.4	4.75	9.51	14.26	19.01	23.77	28.52	33.27	38.02	42.78	.4
15.5	4.78	9.57	14.35	19.14	23.92	28.70	33.49	38.27	43.06	15.5
.6	4.81	9.63	14.44	19.26	24.07	28.89	33.70	38.52	43.33	.6
.7	4.85	9.69	14.54	19.38	24.23	29.07	33.92	38.77	43.61	.7
.8	4.88	9.75	14.63	19.51	24.38	29.26	34.14	39.01	43.89	.8
.9	4.91	9.81	14.72	19.63	24.54	29.44	34.35	39.26	44.17	.9
16.0	4.94	9.88	14.81	19.75	24.69	29.63	34.57	39.51	44.44	16.0
.1	4.97	9.94	14.91	19.88	24.85	29.81	34.78	39.75	44.72	.1
.2	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	.2
.3	5.03	10.06	15.09	20.12	25.15	30.19	35.22	40.25	45.28	.3
.4	5.06	10.12	15.19	20.25	25.31	30.37	35.43	40.49	45.56	.4
16.5	5.09	10.19	15.28	20.37	25.46	30.56	35.65	40.74	45.83	16.5
.6	5.12	10.25	15.37	20.49	25.62	30.74	35.86	40.99	46.11	.6
.7	5.15	10.31	15.46	20.62	25.77	30.93	36.08	41.23	46.39	.7
.8	5.19	10.37	15.56	20.74	25.93	31.11	36.30	41.48	46.67	.8
.9	5.22	10.43	15.65	20.86	26.08	31.30	36.51	41.73	46.94	.9
17.0	5.25	10.49	15.74	20.99	26.23	31.48	36.73	41.98	47.22	17.0
.1	5.28	10.56	15.83	21.11	26.39	31.67	36.94	42.22	47.50	.1
.2	5.31	10.62	15.93	21.23	26.54	31.85	37.16	42.47	47.78	.2
.3	5.34	10.68	16.02	21.36	26.70	32.04	37.38	42.72	48.06	.3
.4	5.37	10.74	16.11	21.48	26.85	32.22	37.59	42.96	48.33	.4
17.5	5.40	10.80	16.20	21.60	27.01	32.41	37.81	43.21	48.61	17.5
.6	5.43	10.86	16.30	21.73	27.16	32.59	38.02	43.46	48.89	.6
.7	5.46	10.93	16.39	21.85	27.31	32.78	38.24	43.70	49.17	.7
.8	5.49	10.99	16.48	21.98	27.47	32.96	38.46	43.95	49.44	.8
.9	5.52	11.05	16.57	22.10	27.62	33.15	38.67	44.20	49.72	.9
	1	2	3	4	5	6	7	8	9	

TABLE XXXI.—PRISMOIDAL CORRECTION. CU. YDS. PER 100 FT

C_0-C_1	1	2	3	4	5	6	7	8	9	C_0-C_1
D_0-D_1										D_0-D_1
18.0	5.56	11.11	16.67	22.22	27.78	33.33	38.89	44.44	50.00	18.0
.1	5.59	11.17	16.76	22.35	27.93	33.52	39.10	44.69	50.28	.1
.2	5.62	11.23	16.85	22.47	28.09	33.70	39.32	44.94	50.56	.2
.3	5.65	11.30	16.94	22.59	28.24	33.89	39.54	45.19	50.83	.3
.4	5.68	11.36	17.04	22.72	28.40	34.07	39.75	45.43	51.11	.4
18.5	5.71	11.42	17.13	22.84	28.55	34.26	39.97	45.68	51.39	18.5
.6	5.74	11.48	17.22	22.96	28.70	34.44	40.19	45.93	51.67	.6
.7	5.77	11.54	17.31	23.09	28.86	34.63	40.40	46.17	51.94	.7
.8	5.80	11.60	17.41	23.21	29.01	34.81	40.62	46.42	52.22	.8
.9	5.83	11.67	17.50	23.33	29.17	35.00	40.83	46.67	52.50	.9
19.0	5.86	11.73	17.59	23.46	29.32	35.19	41.05	46.91	52.78	19.0
.1	5.90	11.79	17.69	23.58	29.48	35.37	41.27	47.16	53.06	.1
.2	5.93	11.85	17.78	23.70	29.63	35.56	41.48	47.41	53.33	.2
.3	5.96	11.91	17.87	23.83	29.78	35.74	41.70	47.65	53.61	.3
.4	5.99	11.98	17.96	23.95	29.94	35.93	41.91	47.90	53.89	.4
19.5	6.02	12.04	18.06	24.07	30.09	36.11	42.13	48.15	54.17	19.5
.6	6.05	12.10	18.15	24.20	30.25	36.30	42.35	48.40	54.44	.6
.7	6.08	12.16	18.24	24.32	30.40	36.48	42.56	48.64	54.72	.7
.8	6.11	12.22	18.33	24.44	30.56	36.67	42.78	48.89	55.00	.8
.9	6.14	12.28	18.43	24.57	30.71	36.85	42.99	49.14	55.28	.9
20.0	6.17	12.35	18.52	24.69	30.86	37.04	43.21	49.38	55.56	20.0
.1	6.20	12.41	18.61	24.81	31.02	37.22	43.43	49.63	55.83	.1
.2	6.23	12.47	18.70	24.94	31.17	37.41	43.64	49.88	56.11	.2
.3	6.27	12.53	18.80	25.06	31.33	37.59	43.86	50.12	56.39	.3
.4	6.30	12.59	18.89	25.19	31.48	37.78	44.07	50.37	56.67	.4
20.5	6.33	12.65	18.98	25.31	31.64	37.96	44.29	50.62	56.94	20.5
.6	6.36	12.72	19.07	25.43	31.79	38.15	44.51	50.86	57.22	.6
.7	6.39	12.78	19.17	25.56	31.94	38.33	44.72	51.11	57.50	.7
.8	6.42	12.84	19.26	25.68	32.10	38.52	44.94	51.36	57.78	.8
.9	6.45	12.90	19.35	25.80	32.25	38.70	45.15	51.60	58.06	.9
21.0	6.48	12.96	19.44	25.93	32.41	38.89	45.37	51.85	58.33	21.0
.1	6.51	13.02	19.54	26.05	32.56	39.07	45.59	52.10	58.61	.1
.2	6.54	13.09	19.63	26.17	32.72	39.26	45.80	52.35	58.89	.2
.3	6.57	13.15	19.72	26.30	32.87	39.44	46.02	52.59	59.17	.3
.4	6.60	13.21	19.81	26.42	33.02	39.63	46.23	52.84	59.44	.4
21.5	6.64	13.27	19.91	26.54	33.18	39.81	46.45	53.09	59.72	21.5
.6	6.67	13.33	20.00	26.67	33.33	40.00	46.67	53.33	60.00	.6
.7	6.70	13.40	20.09	26.79	33.49	40.19	46.88	53.58	60.28	.7
.8	6.73	13.46	20.19	26.91	33.64	40.37	47.10	53.83	60.56	.8
.9	6.76	13.52	20.28	27.04	33.80	40.56	47.31	54.07	60.83	.9
22.0	6.79	13.58	20.37	27.16	33.95	40.74	47.53	54.32	61.11	22.0
.1	6.82	13.64	20.46	27.28	34.10	40.93	47.75	54.57	61.39	.1
.2	6.85	13.70	20.56	27.41	34.26	41.11	47.96	54.81	61.67	.2
.3	6.88	13.77	20.65	27.53	34.41	41.30	48.18	55.06	61.94	.3
.4	6.91	13.83	20.74	27.65	34.57	41.48	48.40	55.31	62.22	.4
22.5	6.94	13.89	20.83	27.78	34.72	41.67	48.61	55.56	62.50	22.5
.6	6.98	13.95	20.93	27.90	34.88	41.85	48.83	55.80	62.78	.6
.7	7.01	14.01	21.02	28.02	35.03	42.04	49.04	56.05	63.06	.7
.8	7.04	14.07	21.11	28.15	35.19	42.22	49.26	56.30	63.33	.8
.9	7.07	14.14	21.20	28.27	35.34	42.41	49.48	56.54	63.61	.9
23.0	7.10	14.20	21.30	28.40	35.49	42.59	49.69	56.79	63.89	23.0
.1	7.13	14.26	21.39	28.52	35.65	42.78	49.91	57.04	64.17	.1
.2	7.16	14.32	21.48	28.64	35.80	42.96	50.12	57.28	64.44	.2
.3	7.19	14.38	21.57	28.77	35.96	43.15	50.34	57.53	64.72	.3
.4	7.22	14.44	21.67	28.89	36.11	43.33	50.56	57.78	65.00	.4
23.5	7.25	14.51	21.76	29.01	36.27	43.52	50.77	58.02	65.28	23.5
.6	7.28	14.57	21.85	29.14	36.42	43.70	50.99	58.27	65.56	.6
.7	7.31	14.63	21.94	29.26	36.57	43.89	51.20	58.52	65.83	.7
.8	7.35	14.69	22.04	29.38	36.73	44.07	51.42	58.77	66.11	.8
.9	7.38	14.75	22.13	29.51	36.88	44.26	51.64	59.01	66.39	.9
	1	2	3	4	5	6	7	8	9	

	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		
c	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	c
0	0.0	6.5	2.6	6.6	5.3	6.8	8.0	6.9	10.8	7.0	13.7	7.2	16.6	7.3	19.5	7.5	22.5	7.6	25.6	7.7	0
1	28.7	7.9	31.9	8.0	35.1	8.1	38.4	8.3	41.7	8.4	45.1	8.6	48.6	8.7	52.1	8.8	55.7	9.0	59.3	9.1	1
2	63.0	9.3	66.7	9.4	70.5	9.5	74.3	9.7	78.2	9.8	82.2	10.0	86.2	10.1	90.3	10.2	94.4	10.4	98.5	10.5	2
3	102.8	10.6	107.1	10.8	111.4	10.9	115.8	11.1	120.3	11.2	124.8	11.3	129.3	11.5	134.0	11.6	138.6	11.8	143.4	11.9	3
4	148.1	12.0	153.0	12.2	157.9	12.3	162.8	12.5	167.9	12.6	172.9	12.7	178.0	12.9	183.2	13.0	188.4	13.1	193.7	13.3	4
5	199.1	13.4	204.5	13.6	209.9	13.7	215.4	13.8	221.0	14.0	226.6	14.1	232.3	14.3	238.0	14.4	243.8	14.5	249.7	14.7	5
6	255.6	14.8	261.5	15.0	267.5	15.1	273.6	15.2	279.7	15.4	285.9	15.5	292.1	15.8	298.4	15.8	304.7	15.9	311.1	16.1	6
7	317.6	16.2	324.1	16.3	330.7	16.5	337.3	16.6	344.0	16.8	350.7	16.9	357.5	17.0	364.3	17.2	371.2	17.3	378.2	17.5	7
8	385.2	17.6	392.3	17.7	399.4	17.9	406.5	18.0	413.8	18.1	421.1	18.3	428.4	18.4	435.8	18.6	443.3	18.7	450.8	18.8	8
9	458.3	19.0	466.0	19.1	473.6	19.3	481.4	19.4	489.1	19.5	497.0	19.7	504.9	19.8	512.8	20.0	520.9	20.1	528.9	20.2	9
10	537.0	20.4	545.2	20.5	553.4	20.6	561.7	20.8	570.1	20.9	578.5	21.1	586.9	21.2	595.4	21.3	604.0	21.5	612.6	21.6	10
11	621.3	21.8	630.0	21.9	638.8	22.0	647.7	22.2	656.6	22.3	665.5	22.5	674.5	22.6	683.6	22.7	692.7	22.9	701.9	23.0	11
12	711.1	23.1	720.4	23.3	729.7	23.4	739.1	23.6	748.6	23.7	758.1	23.8	767.7	24.0	777.3	24.1	787.0	24.3	796.7	24.4	12
13	806.5	24.5	816.3	24.7	826.2	24.8	836.2	25.0	846.2	25.1	856.3	25.2	866.4	25.4	876.5	25.5	886.8	25.6	897.1	25.8	13
14	907.4	25.9	917.8	26.1	928.3	26.2	938.8	26.3	949.3	26.5	960.0	26.6	970.6	26.8	981.4	26.9	992.1	27.0	1003.0	27.2	14
15	1013.9	27.3	1024.8	27.5	1035.9	27.6	1046.9	27.7	1058.0	27.9	1069.2	28.0	1080.4	28.1	1091.7	28.3	1103.1	28.4	1114.5	28.6	15
16	1125.9	28.7	1137.4	28.8	1149.0	29.0	1160.6	29.1	1172.3	29.3	1184.0	29.4	1195.8	29.5	1207.7	29.7	1219.6	29.8	1231.5	30.0	16
17	1243.5	30.1	1255.6	30.2	1267.7	30.4	1279.9	30.5	1292.1	30.6	1304.4	30.8	1316.7	30.9	1329.1	31.1	1341.6	31.2	1354.1	31.3	17
18	1366.7	31.5	1379.3	31.6	1392.0	31.8	1404.7	31.9	1417.5	32.0	1430.3	32.2	1443.2	32.3	1456.2	32.5	1469.2	32.6	1482.3	32.7	18
19	1495.4	32.9	1508.5	33.0	1521.8	33.1	1535.1	33.3	1548.4	33.4	1561.8	33.6	1575.3	33.7	1588.8	33.8	1602.3	34.0	1616.0	34.1	19
20	1629.6	34.3	1643.4	34.4	1657.1	34.5	1671.0	34.7	1684.9	34.8	1698.8	35.0	1712.9	35.1	1726.9	35.2	1741.0	35.4	1755.2	35.5	20
21	1769.4	35.6	1783.7	35.8	1798.1	35.9	1812.5	36.1	1826.9	36.2	1841.4	36.3	1856.0	36.5	1870.6	36.6	1885.3	36.8	1900.0	36.9	21
22	1914.8	37.0	1929.7	37.2	1944.6	37.3	1959.5	37.5	1974.5	37.6	1989.6	37.7	2004.7	37.9	2019.9	38.0	2035.1	38.1	2050.4	38.3	22
23	2065.7	38.4	2081.1	38.6	2096.6	38.7	2112.1	38.8	2127.7	39.0	2143.3	39.1	2159.0	39.3	2174.7	39.5	2190.5	39.6	2206.3	39.7	23
24	2222.2	39.8	2238.2	40.0	2254.2	40.1	2270.3	40.2	2286.4	40.4	2302.5	40.5	2318.8	40.6	2335.1	40.8	2351.4	40.9	2367.8	41.1	24
25	2384.3	41.2	2400.8	41.3	2417.3	41.5	2434.0	41.6	2450.6	41.8	2467.4	41.9	2484.1	42.0	2501.0	42.2	2517.9	42.3	2534.8	42.5	25
26	2551.9	42.6	2568.9	42.7	2586.0	42.9	2603.2	43.0	2620.4	43.1	2637.7	43.3	2655.1	43.4	2672.5	43.6	2689.9	43.7	2707.4	43.8	26
27	2725.0	44.0	2742.6	44.1	2760.3	44.3	2778.0	44.4	2795.8	44.5	2813.7	44.7	2831.6	44.8	2849.5	45.0	2867.5	45.1	2885.6	45.2	27
28	2903.7	45.4	2921.9	45.5	2940.1	45.6	2958.4	45.8	2976.7	45.9	2995.1	46.1	3013.6	46.3	3032.1	46.3	3050.7	46.5	3069.3	46.6	28
29	3088.0	46.8	3106.7	46.9	3125.5	47.0	3144.3	47.2	3163.2	47.3	3182.2	47.5	3201.2	47.6	3220.3	47.7	3239.4	47.9	3258.6	48.0	29

TABLE XXXII.—BASE 15; SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	6.9	2.8	7.1	5.7	7.2	8.6	7.4	11.6	7.5	14.6	7.6	17.7	7.8	20.8	7.9	24.0	8.1	27.2	8.2	0
1	30.6	8.3	33.9	8.5	37.3	8.6	40.8	8.8	44.3	8.9	47.9	9.0	51.6	9.2	55.2	9.3	59.0	9.4	62.8	9.6	1
2	66.7	9.7	70.6	9.9	74.6	10.1	78.6	10.3	82.7	10.4	86.8	10.4	91.0	10.6	95.2	10.7	99.6	10.8	103.9	11.0	2
3	108.3	11.1	112.8	11.2	117.3	11.4	121.9	11.5	126.6	11.7	131.2	11.8	136.0	11.9	140.8	12.1	145.7	12.2	150.6	12.4	3
4	155.6	12.5	160.6	12.6	165.7	12.8	170.8	12.9	176.0	13.1	181.2	13.2	186.6	13.3	191.9	13.5	197.3	13.6	202.8	13.8	4
5	208.3	13.9	213.9	14.0	219.6	14.2	225.2	14.3	231.0	14.4	236.8	14.6	242.7	14.7	248.6	14.9	254.6	15.0	260.6	15.1	5
6	266.7	15.3	272.8	15.4	279.0	15.6	285.2	15.7	291.6	15.8	297.9	16.0	304.3	16.1	310.8	16.2	317.3	16.4	323.9	16.5	6
7	330.6	16.7	337.2	16.8	344.0	16.9	350.8	17.1	357.7	17.2	364.6	17.4	371.6	17.5	378.6	17.6	385.7	17.8	392.8	17.9	7
8	400.0	18.1	407.2	18.2	414.6	18.3	421.9	18.5	429.3	18.6	436.8	18.8	444.3	18.9	451.9	19.0	459.6	19.2	467.2	19.3	8
9	475.0	19.4	482.8	19.6	490.7	19.7	498.6	19.9	506.6	20.0	514.6	20.1	522.7	20.3	530.8	20.4	539.0	20.6	547.2	20.7	9
10	555.6	20.8	563.9	21.0	572.3	21.1	580.8	21.2	589.3	21.4	597.9	21.5	606.6	21.7	615.2	21.8	624.0	21.9	632.8	22.1	10
11	641.7	22.2	650.6	22.4	659.8	22.5	668.8	22.6	677.7	22.8	686.8	22.9	696.0	23.1	705.2	23.2	714.6	23.3	723.9	23.5	11
12	733.3	23.6	742.8	23.8	752.3	23.9	761.9	24.0	771.6	24.2	781.2	24.3	791.0	24.4	800.8	24.6	810.7	24.7	820.6	24.9	12
13	830.6	25.0	840.6	25.1	850.7	25.3	860.8	25.4	871.0	25.6	881.2	25.7	891.6	25.8	901.9	26.0	912.3	26.1	922.8	26.2	13
14	933.3	26.4	943.9	26.5	954.6	26.7	965.2	26.8	976.0	26.9	986.8	27.1	997.7	27.2	1008.6	27.4	1019.6	27.5	1030.6	27.6	14
15	1041.7	27.8	1052.8	27.9	1064.0	28.1	1075.2	28.2	1086.6	28.3	1097.9	28.5	1109.3	28.6	1120.8	28.8	1132.3	28.9	1143.9	29.0	15
16	1155.6	29.2	1167.2	29.3	1179.0	29.4	1190.8	29.6	1202.7	29.7	1214.6	29.9	1226.6	30.0	1238.6	30.1	1250.7	30.3	1262.8	30.4	16
17	1275.0	30.6	1287.2	30.7	1299.6	30.8	1311.9	31.0	1324.3	31.1	1336.8	31.2	1349.3	31.4	1361.9	31.5	1374.6	31.7	1387.2	31.8	17
18	1400.0	31.9	1412.8	32.1	1425.7	32.2	1438.6	32.4	1451.6	32.5	1464.6	32.6	1477.7	32.8	1490.8	32.9	1504.0	33.1	1517.2	33.2	18
19	1530.6	33.3	1543.9	33.5	1557.3	33.6	1570.8	33.8	1584.3	33.9	1597.9	34.0	1611.6	34.2	1625.2	34.3	1639.0	34.4	1652.8	34.6	19
20	1666.7	34.7	1680.6	34.9	1694.6	35.0	1708.6	35.1	1722.7	35.3	1736.8	35.4	1751.0	35.6	1765.2	35.7	1779.6	35.8	1793.9	36.0	20
21	1808.3	36.1	1822.8	36.2	1837.3	36.4	1851.9	36.5	1866.6	36.7	1881.2	36.8	1896.0	36.9	1910.8	37.1	1925.7	37.2	1940.6	37.4	21
22	1955.6	37.5	1970.6	37.6	1985.7	37.8	2000.8	37.9	2016.0	38.1	2031.2	38.2	2046.6	38.3	2061.9	38.5	2077.3	38.6	2092.8	38.8	22
23	2108.3	38.9	2123.9	39.0	2139.6	39.2	2155.2	39.3	2171.0	39.4	2186.8	39.6	2202.7	39.7	2218.6	39.9	2234.6	40.0	2250.6	40.1	23
24	2266.7	40.3	2282.8	40.4	2299.0	40.6	2315.2	40.7	2331.6	40.8	2347.9	41.0	2364.3	41.1	2380.8	41.2	2397.3	41.4	2413.9	41.5	24
25	2430.6	41.7	2447.2	41.8	2464.0	41.9	2480.8	42.1	2497.7	42.2	2514.6	42.4	2531.6	42.5	2548.6	42.6	2565.7	42.8	2582.8	42.9	25
26	2600.0	43.1	2617.2	43.2	2634.6	43.3	2651.9	43.5	2669.3	43.6	2686.8	43.8	2704.3	43.9	2721.9	44.0	2739.6	44.2	2757.2	44.3	26
27	2775.6	44.4	2793.4	44.6	2810.7	44.7	2828.6	44.9	2846.6	45.0	2864.6	45.1	2882.7	45.3	2900.8	45.4	2919.0	45.6	2937.2	45.7	27
28	2955.7	45.8	2973.9	46.0	2992.3	46.1	3010.8	46.2	3029.3	46.4	3047.9	46.5	3066.6	46.7	3085.2	46.8	3104.0	46.9	3122.8	47.1	28
29	3141.7	47.2	3160.6	47.4	3179.6	47.5	3198.6	47.6	3217.7	47.8	3236.8	47.9	3256.0	48.1	3275.2	48.2	3294.6	48.3	3313.9	48.5	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	7.4	3.0	7.5	6.0	7.7	9.1	7.8	12.3	8.0	15.5	8.1	18.8	8.2	22.1	8.4	25.5	8.5	28.9	8.7	0
1	32.4	8.8	36.0	8.9	39.6	9.1	43.2	9.2	46.9	9.4	50.7	9.5	54.5	9.6	58.4	9.8	62.3	9.9	66.3	10.0	1
2	70.4	10.2	74.5	10.3	78.6	10.5	82.8	10.6	87.1	10.7	91.4	10.9	95.8	11.0	100.2	11.2	104.7	11.3	109.3	11.4	2
3	113.9	11.6	118.5	11.7	123.3	11.9	128.0	12.0	132.9	12.1	137.7	12.3	142.7	12.4	147.7	12.5	152.7	12.7	157.8	12.8	3
4	163.0	13.0	168.2	13.1	173.4	13.2	178.8	13.4	184.1	13.5	189.6	13.7	195.1	13.8	200.6	13.9	206.2	14.1	211.9	14.2	4
5	217.6	14.4	223.4	14.5	229.2	14.6	235.1	14.8	241.0	14.9	247.0	15.0	253.0	15.2	259.1	15.3	265.3	15.5	271.5	15.6	5
6	277.8	15.7	284.1	15.9	290.5	16.0	296.9	16.2	303.4	16.3	310.0	16.4	316.6	16.6	323.2	16.7	329.9	16.9	336.7	17.0	6
7	343.5	17.1	350.4	17.3	357.3	17.4	364.3	17.5	371.4	17.7	378.5	17.8	385.6	18.0	392.8	18.1	400.1	18.2	407.4	18.4	7
8	414.8	18.5	422.2	18.7	429.7	18.8	437.3	18.9	444.9	19.1	452.5	19.2	460.3	19.4	468.0	19.5	475.9	19.6	483.7	19.8	8
9	491.7	19.9	499.7	20.0	507.7	20.2	515.8	20.3	524.0	20.5	532.2	20.6	540.4	20.7	548.8	20.9	557.1	21.0	565.6	21.2	9
10	574.1	21.3	582.6	21.4	591.2	21.6	599.9	21.7	608.6	21.9	617.4	22.0	626.2	22.1	635.1	22.3	644.0	22.4	653.0	22.5	10
11	662.0	22.7	671.1	22.8	680.3	23.0	689.5	23.1	698.8	23.2	708.1	23.4	717.5	23.5	726.9	23.7	736.4	23.8	746.0	23.9	11
12	755.6	24.1	765.2	24.2	774.9	24.4	784.7	24.5	794.5	24.6	804.4	24.8	814.3	24.9	824.3	25.0	834.4	25.2	844.5	25.3	12
13	854.6	25.5	864.8	25.6	875.1	25.7	885.4	25.9	895.8	26.0	906.2	26.2	916.7	26.3	927.3	26.4	937.9	26.6	948.5	26.7	13
14	959.3	26.9	970.0	27.0	980.9	27.1	991.7	27.3	1002.7	27.4	1013.7	27.5	1024.7	27.7	1035.8	27.8	1047.0	28.0	1058.2	28.1	14
15	1069.4	28.2	1080.8	28.4	1092.1	28.5	1103.6	28.7	1115.1	28.8	1126.6	28.9	1138.2	29.1	1149.9	29.2	1161.6	29.4	1173.4	29.5	15
16	1185.2	29.6	1197.1	29.8	1209.0	29.9	1221.0	30.0	1233.0	30.2	1245.1	30.3	1257.3	30.5	1269.5	30.6	1281.8	30.7	1294.1	30.9	16
17	1306.5	31.0	1318.9	31.2	1331.4	31.3	1344.0	31.4	1356.6	31.6	1369.2	31.7	1381.9	31.9	1394.7	32.0	1407.5	32.1	1420.4	32.3	17
18	1433.3	32.4	1446.3	32.5	1459.4	32.7	1472.5	32.8	1485.6	33.0	1498.8	33.1	1512.1	33.2	1525.4	33.4	1538.8	33.5	1552.2	33.7	18
19	1565.7	33.8	1579.3	33.9	1592.9	34.1	1606.5	34.2	1620.3	34.4	1634.0	34.5	1647.9	34.6	1661.7	34.8	1675.7	34.9	1689.7	35.0	19
20	1703.7	35.2	1717.8	35.3	1732.0	35.5	1746.2	35.6	1760.4	35.7	1774.8	35.9	1789.1	36.0	1803.6	36.2	1818.1	36.3	1832.6	36.4	20
21	1847.2	36.6	1861.9	36.7	1876.6	36.9	1891.4	37.0	1906.2	37.1	1921.1	37.3	1936.0	37.4	1951.0	37.5	1966.0	37.7	1981.1	37.8	21
22	1996.3	38.0	2011.5	38.1	2026.8	38.2	2042.1	38.4	2057.5	38.5	2072.9	38.7	2088.4	38.8	2104.0	38.9	2119.6	39.1	2135.2	39.2	22
23	2150.9	39.4	2166.7	39.5	2182.5	39.6	2198.4	39.8	2214.3	39.9	2230.3	40.0	2246.4	40.2	2262.5	40.3	2278.6	40.5	2294.8	40.6	23

c	.0		.1		.2		.3		.4		18 .5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	8.3	3.4	8.5	6.8	8.6	10.2	8.8	13.8	8.9	17.4	9.0	21.0	9.2	24.7	9.3	28.4	9.4	32.2	9.6	0
1	36.1	9.7	40.0	9.9	44.0	10.0	48.0	10.1	52.1	10.3	56.2	10.4	60.4	10.6	64.7	10.7	69.0	10.8	73.4	11.0	1
2	77.8	11.1	82.2	11.2	86.8	11.4	91.4	11.5	96.0	11.7	100.7	11.8	105.4	11.9	110.2	12.1	115.1	12.2	120.0	12.4	2
3	125.0	12.5	130.0	12.6	135.1	12.8	140.2	12.9	145.4	13.1	150.7	13.2	156.0	13.3	161.4	13.5	166.8	13.6	172.2	13.8	3
4	177.8	13.9	183.4	14.0	189.0	14.2	194.7	14.3	200.4	14.4	206.2	14.6	212.1	14.7	218.0	14.9	224.0	15.0	230.0	15.1	4
5	236.1	15.3	242.2	15.4	248.4	15.6	254.7	15.7	261.0	15.8	267.4	16.0	273.8	16.1	280.2	16.2	286.8	16.4	293.4	16.5	5
6	300.0	16.7	306.7	16.8	313.4	16.9	320.2	17.1	327.1	17.2	334.0	17.4	341.0	17.5	348.0	17.6	355.1	17.8	362.2	17.9	6
7	369.4	18.1	376.7	18.2	384.0	18.3	391.4	18.5	398.8	18.6	406.2	18.8	413.8	18.9	421.4	19.0	429.0	19.2	436.7	19.3	7
8	444.4	19.4	452.2	19.6	460.1	19.7	468.0	19.9	476.0	20.0	484.0	20.1	492.1	20.3	500.2	20.4	508.4	20.6	516.7	20.7	8
9	525.0	20.8	533.4	21.0	541.8	21.1	550.2	21.2	558.8	21.4	567.4	21.5	576.0	21.7	584.7	21.8	593.4	21.9	602.2	22.1	9
10	611.1	22.2	620.0	22.4	629.0	22.5	638.0	22.6	647.1	22.8	656.2	22.9	665.4	23.1	674.7	23.2	684.0	23.3	693.4	23.5	10
11	702.8	23.6	712.2	23.8	721.8	23.9	731.4	24.0	741.0	24.2	750.7	24.3	760.4	24.4	770.2	24.6	780.1	24.7	790.0	24.9	11
12	800.0	25.0	810.0	25.1	820.1	25.3	830.2	25.4	840.4	25.6	850.7	25.7	861.0	25.8	871.4	26.0	881.8	26.1	892.2	26.2	12
13	902.8	26.4	913.4	26.5	924.0	26.7	934.7	26.8	945.4	26.9	956.2	27.1	967.1	27.2	978.0	27.4	989.0	27.5	1000.0	27.6	13
14	1011.1	27.8	1022.2	27.9	1033.4	28.1	1044.7	28.2	1056.0	28.3	1067.4	28.5	1078.8	28.6	1090.2	28.8	1101.8	28.9	1113.4	29.0	14
15	1125.0	29.2	1136.7	29.3	1148.4	29.4	1160.2	29.6	1172.1	29.7	1184.0	29.9	1196.0	30.0	1208.0	30.1	1220.1	30.3	1232.2	30.4	15
16	1244.4	30.6	1256.7	30.7	1269.0	30.8	1281.4	31.0	1293.8	31.1	1306.2	31.2	1318.8	31.4	1331.4	31.5	1344.0	31.7	1356.7	31.8	16
17	1369.4	31.9	1382.2	32.1	1395.1	32.2	1408.0	32.4	1421.0	32.5	1434.0	32.6	1447.1	32.8	1460.2	32.9	1473.4	33.1	1486.7	33.2	17
18	1500.0	33.3	1513.4	33.5	1526.8	33.6	1540.2	33.8	1553.8	33.9	1567.4	34.0	1581.0	34.2	1594.7	34.3	1608.4	34.4	1622.2	34.6	18
19	1636.1	34.7	1650.0	34.9	1664.0	35.0	1678.0	35.1	1692.1	35.3	1706.2	35.4	1720.4	35.6	1734.7	35.7	1749.0	35.8	1763.4	36.0	19
20	1777.8	36.1	1792.2	36.2	1806.8	36.4	1821.4	36.5	1836.0	36.7	1850.7	36.8	1865.4	36.9	1880.2	37.1	1895.1	37.2	1910.0	37.4	20
21	1925.0	37.5	1940.0	37.6	1955.1	37.8	1970.2	37.9	1985.4	38.1	2000.7	38.2	2016.0	38.3	2031.4	38.5	2046.8	38.6	2062.2	38.8	21
22	2077.8	38.9	2093.4	39.0	2109.0	39.2	2124.7	39.3	2140.4	39.4	2156.2	39.6	2172.1	39.7	2188.0	39.9	2204.0	40.0	2220.0	40.1	22
23	2236.1	40.3	2252.2	40.4	2268.4	40.6	2284.7	40.7	2301.0	40.8	2317.4	41.0	2333.8	41.1	2350.2	41.2	2366.8	41.4	2383.4	41.5	23
24	2400.0	41.7	2416.7	41.8	2433.4	41.9	2450.2	42.1	2467.1	42.2	2484.0	42.4	2501.0	42.5	2518.0	42.6	2535.1	42.8	2552.2	42.9	24
25	2569.4	43.1	2586.7	43.2	2604.0	43.3	2621.4	43.5	2638.8	43.6	2656.2	43.8	2673.8	43.9	2691.4	44.0	2709.0	44.2	2726.7	44.3	25
26	2744.4	44.4	2762.2	44.6	2780.1	44.7	2798.0	44.9	2816.0	45.0	2834.0	45.1	2852.1	45.3	2870.2	45.4	2888.4	45.6	2906.7	45.7	26
27	2925.1	45.8	2943.4	46.0	2961.8	46.1	2980.2	46.2	2998.8	46.4	3017.4	46.5	3036.0	46.7	3054.7	46.8	3073.4	46.9	3092.2	47.1	27
28	3111.5	47.2	3130.0	47.4	3149.0	47.5	3168.0	47.6	3187.1	47.8	3206.2	47.9	3225.4	48.1	3244.7	48.2	3264.0	48.3	3283.4	48.5	28
29	3302.0	48.6	3322.2	48.8	3341.8	48.9	3361.4	49.0	3381.0	49.2	3400.7	49.3	3420.4	49.4	3440.2	49.6	3460.1	49.7	3480.0	49.9	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 20: SLOPE 1¼ TO 1. CU. YDS. PER 50 FT.

20

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	9.3	3.7	9.4	7.5	9.5	11.4	9.7	15.3	9.8	19.2	10.0	23.2	10.1	27.3	10.2	31.4	10.4	35.6	10.5	0
1	39.8	10.6	44.1	10.8	48.4	10.9	52.8	11.1	57.3	11.2	61.8	11.3	66.4	11.5	71.0	11.6	75.7	11.8	80.4	11.9	1
2	85.2	12.0	90.0	12.2	94.9	12.3	99.9	12.5	104.9	12.6	110.0	12.7	115.1	12.9	120.2	13.0	125.5	13.1	130.8	13.3	2
3	136.1	13.4	141.5	13.6	147.0	13.7	152.5	13.8	158.0	14.0	163.7	14.1	169.3	14.3	175.1	14.4	180.9	14.5	186.7	14.7	3
4	192.6	14.8	198.5	15.0	204.6	15.1	210.6	15.2	216.7	15.4	222.9	15.5	229.1	15.6	235.4	15.8	241.8	15.9	248.2	16.1	4
5	254.6	16.2	261.1	16.3	267.7	16.5	274.3	16.6	281.0	16.8	287.7	16.9	294.5	17.0	301.4	17.2	308.3	17.3	315.2	17.5	5
6	322.2	17.6	329.3	17.7	336.4	17.9	343.6	18.0	350.8	18.1	358.1	18.3	365.4	18.4	372.8	18.6	380.3	18.7	387.8	18.8	6
7	395.4	19.0	403.0	19.1	410.7	19.3	418.4	19.4	426.2	19.5	434.0	19.7	441.9	19.8	449.9	20.0	457.9	20.1	466.0	20.2	7
8	474.1	20.4	482.2	20.5	490.5	20.6	498.8	20.8	507.1	20.9	515.5	21.1	524.0	21.2	532.5	21.3	541.0	21.5	549.7	21.6	8
9	558.3	21.8	567.1	21.9	575.9	22.0	584.7	22.2	593.6	22.3	602.5	22.5	611.6	22.6	620.6	22.7	629.7	22.9	638.9	23.0	9
10	648.1	23.1	657.4	23.3	666.8	23.4	676.2	23.6	685.6	23.7	695.1	23.8	704.7	24.0	714.3	24.1	724.0	24.3	733.7	24.4	10
11	743.5	24.5	753.4	24.7	763.3	24.8	773.2	25.0	783.2	25.1	793.3	25.2	803.4	25.4	813.6	25.5	823.8	25.6	834.1	25.8	11
12	844.4	25.9	854.8	26.1	865.3	26.2	875.8	26.3	886.4	26.5	897.0	26.6	907.7	26.8	918.4	26.9	929.2	27.0	940.0	27.2	12
13	950.9	27.3	961.9	27.5	972.9	27.6	984.0	27.7	995.1	27.9	1006.2	28.0	1017.5	28.1	1028.8	28.3	1040.1	28.4	1051.5	28.6	13
14	1063.0	28.7	1074.5	28.8	1086.0	29.0	1097.7	29.1	1109.3	29.3	1121.1	29.4	1132.9	29.5	1144.7	29.7	1156.6	29.8	1168.5	30.0	14
15	1180.6	30.1	1192.6	30.2	1204.7	30.4	1216.9	30.5	1229.1	30.6	1241.4	30.8	1253.8	30.9	1266.2	31.1	1278.6	31.2	1291.1	31.3	15
16	1303.7	31.5	1316.3	31.6	1329.0	31.8	1341.7	31.9	1354.5	32.0	1367.4	32.2	1380.3	32.3	1393.2	32.5	1406.2	32.6	1419.3	32.7	16
17	1432.4	32.9	1445.6	33.0	1458.8	33.1	1472.1	33.3	1485.4	33.4	1498.8	33.6	1512.3	33.7	1525.8	33.8	1539.4	34.0	1553.0	34.1	17
18	1566.7	34.3	1580.4	34.4	1594.2	34.5	1608.0	34.7	1621.9	34.8	1635.9	35.0	1649.9	35.1	1664.0	35.2	1678.1	35.4	1692.2	35.5	18
19	1706.5	35.6	1720.8	35.8	1735.1	35.9	1749.5	36.1	1764.0	36.2	1778.5	36.3	1793.0	36.5	1807.7	36.6	1822.3	36.8	1837.1	36.9	19
20	1851.9	37.0	1866.7	37.2	1881.	37.3	1896.5	37.5	1911.6	37.6	1926.6	37.7	1941.7	37.9	1956.9	38.0	1972.1	38.1	1987.4	38.3	20
21	2002.8	38.4	2018.2	38.6	2033.6	38.7	2049.1	38.8	2064.7	39.0	2080.3	39.1	2096.0	39.3	2111.7	39.4	2127.5	39.5	2143.4	39.7	21
22	2159.3	39.8	2175.2	40.0	2191.2	40.1	2207.3	40.2	2223.4	40.4	2239.6	40.5	2255.8	40.6	2272.1	40.8	2288.4	40.9	2304.8	41.1	22
23	2321.3	41.2	2337.8	41.3	2354.4	41.5	2371.0	41.6	2387.7	41.8	2404.4	41.9	2421.2	42.0	2438.0	42.2	2454.9	42.3	2471.9	42.5	23
24	2488.9	42.6	2506.0	42.7	2523.1	42.9	2540.2	43.0	2557.5	43.1	2574.8	43.3	2592.1	43.4	2609.5	43.6	2627.0	43.7	2644.5	43.8	24
25	2662.0	44.0	2679.7	44.1	2697.3	44.3	2715.1	44.4	2732.9	44.5	2750.7	44.7	2768.6	44.8	2786.5	45.0	2804.6	45.1	2822.6	45.2	25
26	2840.7	45.4	2858.9	45.5	2877.1	45.6	2895.4	45.8	2913.8	45.9	2932.2	46.1	2950.6	46.2	2969.1	46.3	2987.7	46.5	3006.3	46.6	26
27	3025.0	46.8	3043.7	46.9	3062.5	47.0	3081.4	47.2	3100.3	47.3	3119.2	47.5	3138.2	47.6	3157.3	47.7	3176.4	47.9	3195.6	48.0	27
28	3214.8	48.1	3234.1	48.3	3253.4	48.4	3272.8	48.6	3292.3	48.7	3311.8	48.8	3331.4	49.0	3351.0	49.1	3370.7	49.3	3390.4	49.4	28
29	3410.2	49.5	3430.0	49.7	3449.9	49.8	3469.9	50.0	3489.9	50.1	3510.0	50.2	3530.1	50.4	3550.2	50.5	3570.5	50.6	3590.8	50.8	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 21; SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	9.7	3.9	9.9	7.9	10.0	11.9	10.1	16.0	10.3	20.1	10.4	24.3	10.6	28.6	10.7	32.9	10.8	37.2	11.0	0
1	41.7	11.1	46.1	11.2	50.7	11.4	55.2	11.5	59.9	11.7	64.6	11.8	69.3	11.9	74.1	12.1	79.0	12.2	83.9	12.4	1
2	88.9	12.5	93.9	12.6	99.0	12.8	104.1	12.9	109.3	13.1	114.6	13.2	119.9	13.3	125.2	13.5	130.7	13.6	136.1	13.8	2
3	141.7	13.9	147.2	14.0	152.9	14.2	158.6	14.3	164.3	14.4	170.1	14.6	176.0	14.7	181.9	14.9	187.9	15.0	193.9	15.1	3
4	200.0	15.3	206.1	15.4	212.3	15.6	218.6	15.7	224.9	15.8	231.2	16.0	237.7	16.1	244.1	16.2	250.7	16.4	257.2	16.5	4
5	263.9	16.7	270.6	16.8	277.3	16.9	284.1	17.1	291.0	17.2	297.9	17.4	304.9	17.5	311.9	17.6	319.0	17.8	326.1	17.9	5
6	333.3	18.1	340.6	18.2	347.9	18.3	355.2	18.5	362.7	18.6	370.1	18.8	377.7	18.9	385.2	19.0	392.9	19.2	400.6	19.3	6
7	408.3	19.4	416.1	19.6	424.0	19.7	431.9	19.9	439.9	20.0	447.9	20.1	456.0	20.3	464.1	20.4	472.3	20.6	480.6	20.7	7
8	488.9	20.8	497.2	21.0	505.7	21.1	514.1	21.2	522.7	21.4	531.2	21.5	539.9	21.7	548.6	21.8	557.3	21.9	566.1	22.1	8
9	575.0	22.2	583.9	22.4	592.9	22.5	601.9	22.6	611.0	22.8	620.1	22.9	629.3	23.1	638.6	23.2	647.9	23.3	657.2	23.5	9
10	666.7	23.6	676.1	23.8	685.7	23.9	695.2	24.0	704.9	24.2	714.6	24.3	724.3	24.4	734.1	24.6	744.0	24.7	753.9	24.9	10
11	763.9	25.0	773.9	25.1	784.0	25.3	794.1	25.4	804.3	25.6	814.6	25.7	824.9	25.8	835.2	26.0	845.7	26.1	856.1	26.2	11
12	866.7	26.4	877.2	26.5	887.9	26.7	898.6	26.8	909.3	26.9	920.1	27.1	931.0	27.2	941.9	27.4	952.9	27.5	963.9	27.6	12
13	975.0	27.8	986.1	27.9	997.3	28.1	1008.6	28.2	1019.9	28.3	1031.2	28.5	1042.7	28.6	1054.1	28.8	1065.7	28.9	1077.2	29.0	13
14	1088.9	29.2	1100.6	29.3	1112.3	29.4	1124.1	29.6	1136.0	29.7	1147.9	29.9	1159.9	30.0	1171.9	30.1	1184.0	30.3	1196.1	30.4	14
15	1208.3	30.6	1220.6	30.7	1232.9	30.8	1245.2	31.0	1257.7	31.1	1270.1	31.2	1282.7	31.4	1295.2	31.5	1307.9	31.7	1320.6	31.8	15
16	1333.3	31.9	1346.1	32.1	1359.0	32.2	1371.9	32.4	1384.9	32.5	1397.9	32.6	1411.0	32.8	1424.1	32.9	1437.3	33.1	1450.6	33.2	16
17	1463.9	33.3	1477.2	33.5	1490.7	33.6	1504.1	33.8	1517.7	33.9	1531.2	34.0	1544.9	34.2	1558.6	34.3	1572.3	34.4	1586.1	34.6	17
18	1600.0	34.7	1613.9	34.9	1627.9	35.0	1641.9	35.1	1656.0	35.3	1670.1	35.4	1684.3	35.6	1698.6	35.7	1712.9	35.8	1727.2	36.0	18
19	1741.7	36.1	1756.1	36.2	1770.7	36.4	1785.2	36.5	1799.9	36.7	1814.6	36.8	1829.3	36.9	1844.1	37.1	1859.0	37.2	1873.9	37.4	19
20	1888.9	37.5	1903.9	37.6	1919.0	37.8	1934.1	37.9	1949.3	38.1	1964.6	38.2	1979.9	38.3	1995.2	38.5	2010.7	38.6	2026.1	38.8	20
21	2041.7	38.9	2057.2	39.0	2072.9	39.2	2088.6	39.3	2104.3	39.4	2120.1	39.6	2136.0	39.7	2151.9	39.9	2167.9	40.0	2183.9	40.1	21
22	2200.0	40.3	2216.1	40.4	2232.3	40.6	2248.6	40.7	2264.9	40.8	2281.2	41.0	2297.7	41.1	2314.1	41.2	2330.7	41.4	2347.2	41.5	22
23	2363.9	41.7	2380.6	41.8	2397.3	41.9	2414.1	42.1	2431.0	42.2	2447.9	42.4	2464.9	42.5	2481.9	42.6	2499.0	42.8	2516.1	42.9	23
24	2533.3	43.1	2550.6	43.2	2567.9	43.3	2585.2	43.5	2602.7	43.6	2620.1	43.8	2637.7	43.9	2655.2	44.0	2672.9	44.2	2690.6	44.3	24
25	2708.3	44.4	2726.1	44.6	2744.0	44.7	2761.9	44.9	2779.9	45.0	2797.9	45.1	2816.0	45.3	2834.1	45.4	2852.3	45.6	2870.6	45.7	25
26	2888.9	45.8	2907.2	46.0	2925.7	46.1	2944.1	46.2	2962.7	46.4	2981.2	46.5	2999.9	46.7	3018.6	46.8	3037.3	46.9	3056.1	47.1	26
27	3075.0	47.2	3093.9	47.4	3112.9	47.5	3131.9	47.6	3151.0	47.8	3170.1	47.9	3189.3	48.1	3208.6	48.2	3227.9	48.3	3247.2	48.5	27
28	3265.9	48.6	3286.1	48.8	3305.7	48.9	3325.2	49.0	3344.9	49.2	3364.6	49.3	3384.3	49.4	3404.1	49.6	3424.0	49.7	3443.9	49.9	28
29	3465.9	50.0	3483.9	50.1	3504.0	50.3	3524.1	50.4	3544.3	50.6	3564.6	50.7	3584.9	50.8	3605.2	51.0	3625.7	51.1	3646.1	51.2	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 22: SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	10.2	4.1	10.3	8.3	10.5	12.5	10.6	16.7	10.7	21.1	10.9	25.4	11.0	29.9	11.2	34.4	11.3	38.9	11.4	0
1	43.5	11.6	48.2	11.7	52.9	11.9	57.7	12.0	62.5	12.1	67.4	12.3	72.3	12.4	77.3	12.5	82.3	12.7	87.4	12.8	1
2	92.6	13.0	97.8	13.1	103.1	13.2	108.4	13.4	113.8	13.5	119.2	13.7	124.7	13.8	130.2	13.9	135.9	14.1	141.5	14.2	2
3	147.2	14.4	153.0	14.5	158.8	14.6	164.7	14.8	170.6	14.9	176.6	15.0	182.7	15.2	188.8	15.3	194.9	15.5	201.1	15.6	3
4	207.4	15.7	213.7	15.9	220.1	16.0	226.5	16.2	233.0	16.3	239.6	16.4	246.2	16.6	252.8	16.7	259.6	16.9	266.3	17.0	4
5	273.1	17.1	280.0	17.3	287.0	17.4	294.0	17.5	301.0	17.7	308.1	17.8	315.3	18.0	322.5	18.1	329.7	18.2	337.1	18.4	5
6	344.4	18.5	351.9	18.7	359.4	18.8	366.9	18.9	374.5	19.1	382.2	19.2	389.9	19.4	397.7	19.5	405.5	19.6	413.4	19.8	6
7	421.3	19.9	429.3	20.0	437.3	20.2	445.4	20.3	453.6	20.5	461.8	20.6	470.1	20.7	478.4	20.9	486.8	21.0	495.2	21.2	7
8	503.7	21.3	512.2	21.4	520.9	21.6	529.5	21.7	538.2	21.9	547.0	22.0	555.8	22.1	564.7	22.3	573.6	22.4	582.6	22.5	8
9	591.7	22.7	600.8	22.8	609.9	23.0	619.1	23.1	628.4	23.2	637.7	23.4	647.1	23.5	656.5	23.7	666.0	23.8	675.6	23.9	9
10	685.2	24.1	694.8	24.2	704.6	24.4	714.3	24.5	724.1	24.6	734.0	24.8	744.0	24.9	754.0	25.0	764.0	25.2	774.1	25.3	10
11	784.3	25.5	794.5	25.6	804.7	25.7	815.1	25.9	825.4	26.0	835.9	26.2	846.4	26.3	856.9	26.4	867.5	26.6	878.2	26.7	11
12	888.9	26.9	899.7	27.0	910.5	27.1	941.4	27.3	932.3	27.4	943.3	27.5	954.3	27.7	965.4	27.8	976.6	28.0	987.8	28.1	12
13	999.1	28.2	1010.4	28.4	1021.8	28.5	1033.2	28.7	1044.7	28.8	1056.2	28.9	1067.9	29.1	1079.5	29.2	1091.2	29.4	1103.0	29.5	13
14	1114.8	29.6	1126.7	29.8	1138.6	29.9	1150.6	30.0	1162.7	30.2	1174.8	30.3	1186.9	30.5	1199.1	30.6	1211.4	30.7	1223.7	30.9	14
15	1236.1	31.0	1248.5	31.2	1261.0	31.3	1273.6	31.4	1286.2	31.6	1298.8	31.7	1311.6	31.9	1324.3	32.0	1337.1	32.1	1350.0	32.3	15
16	1363.0	32.4	1376.0	32.5	1389.0	32.7	1402.1	32.8	1415.3	33.0	1428.5	33.1	1441.7	33.2	1455.1	33.4	1468.4	33.5	1481.9	33.7	16
17	1495.4	33.8	1508.9	33.9	1522.5	34.1	1536.2	34.2	1549.9	34.4	1563.7	34.5	1577.5	34.6	1591.4	34.8	1605.3	34.9	1619.3	35.0	17
18	1633.3	35.2	1647.4	35.3	1661.6	35.5	1675.8	35.6	1690.1	35.7	1704.4	35.9	1718.8	36.0	1733.2	36.2	1747.7	36.3	1762.2	36.4	18
19	1776.9	36.6	1791.5	36.7	1806.2	36.9	1821.0	37.0	1835.8	37.1	1850.7	37.3	1865.6	37.4	1880.6	37.5	1895.7	37.7	1910.8	37.8	19
20	1925.9	38.0	1941.1	38.1	1956.4	38.2	1971.7	38.4	1987.1	38.5	2002.5	38.7	2018.0	38.8	2033.6	38.9	2049.2	39.1	2064.8	39.2	20
21	2080.6	39.4	2096.3	39.5	2112.1	39.6	2128.0	39.8	2144.0	39.9	2160.0	40.0	2176.0	40.2	2192.1	40.3	2208.3	40.5	2224.5	40.6	21
22	2240.7	40.7	2257.1	40.9	2273.4	41.0	2289.9	41.2	2306.4	41.3	2322.9	41.4	2339.5	41.6	2356.2	41.7	2372.9	41.9	2389.7	42.0	22
23	2406.5	42.1	2423.4	42.3	2440.3	42.4	2457.3	42.5	2474.3	42.7	2491.4	42.8	2508.6	43.0	2525.8	43.1	2543.1	43.2	2560.4	43.4	23
24	2577.8	43.5	2595.2	43.7	2612.7	43.8	2630.2	43.9	2647.9	44.1	2665.5	44.2	2683.2	44.4	2701.0	44.5	2718.8	44.6	2736.7	44.8	24
25	2754.6	44.9	2772.6	45.0	2790.7	45.2	2808.8	45.3	2826.9	45.5	2845.1	45.6	2863.4	45.7	2881.7	45.9	2900.1	46.0	2918.5	46.2	25
26	2937.0	46.3	2955.6	46.4	2974.2	46.6	2992.8	46.7	3011.6	46.9	3030.3	47.0	3049.1	47.1	3068.0	47.3	3087.0	47.4	3106.0	47.5	26
27	3125.0	47.7	3144.1	47.8	3163.3	48.0	3182.5	48.1	3201.7	48.2	3221.1	48.4	3240.4	48.5	3259.9	48.7	3279.4	48.8	3298.9	48.9	27
28	3318.5	49.1	3338.2	49.2	3357.9	49.4	3377.7	49.5	3397.5	49.6	3417.4	49.8	3437.3	49.9	3457.3	50.0	3477.3	50.2	3497.4	50.3	28
29	3517.6	50.5	3537.8	50.6	3558.1	50.7	3578.4	50.9	3598.8	51.0	3619.2	51.2	3639.7	51.3	3660.2	51.4	3680.9	51.6	3701.5	51.7	29

c	.0 L.	.0 K.	.1 L.	.1 K.	.2 L.	.2 K.	.3 L.	.3 K.	.4 L.	.4 K.	.5 L.	.5 K.	.6 L.	.6 K.	.7 L.	.7 K.	.8 L.	.8 K.	.9 L.	.9 K.	c
0	0.0	10.6	4.3	10.8	8.6	10.9	13.0	11.1	17.5	11.2	22.0	11.3	26.6	11.5	31.2	11.6	35.9	11.8	40.6	11.9	0
1	45.4	12.0	50.2	12.2	55.1	12.3	60.1	12.5	65.1	12.6	70.1	12.7	75.3	12.9	80.4	13.0	85.7	13.1	91.0	13.3	1
2	96.3	13.4	101.7	13.6	107.1	13.7	112.7	13.8	118.2	14.0	123.8	14.1	129.5	14.3	135.2	14.4	141.0	14.5	146.9	14.7	2
3	152.8	14.8	158.7	15.0	164.7	15.1	170.8	15.2	176.9	15.4	183.1	15.5	189.3	15.6	195.6	15.8	202.0	15.9	208.4	16.1	3
4	214.8	16.2	221.3	16.3	227.9	16.5	234.5	16.6	241.2	16.8	247.9	16.9	254.7	17.0	261.5	17.2	268.4	17.3	275.4	17.5	4
5	282.4	17.6	289.5	17.7	296.6	17.9	303.8	18.0	311.0	18.1	318.3	18.3	325.6	18.4	333.0	18.6	340.5	18.7	348.0	18.8	5
6	355.6	19.0	363.2	19.1	370.9	19.3	378.6	19.4	386.4	19.5	394.2	19.7	402.1	19.8	410.1	20.0	418.1	20.1	426.1	20.2	6
7	434.3	20.4	442.4	20.5	450.7	20.6	459.0	20.8	467.3	20.9	475.7	21.1	484.1	21.2	492.7	21.3	501.2	21.5	509.8	21.6	7
8	518.5	21.8	527.2	21.9	536.0	22.0	544.9	22.2	553.8	22.3	562.7	22.5	571.7	22.6	580.8	22.7	589.9	22.9	599.1	23.0	8
9	608.3	23.1	617.6	23.3	627.0	23.4	636.4	23.6	645.8	23.7	655.3	23.8	664.9	24.0	674.5	24.1	684.2	24.3	693.9	24.4	9
10	703.7	24.5	713.5	24.7	723.4	24.8	733.4	25.0	743.4	25.1	753.5	25.2	763.6	25.4	773.8	25.5	784.0	25.6	794.3	25.8	10
11	804.6	25.9	815.0	26.1	825.5	26.2	836.0	26.3	846.6	26.5	857.2	26.6	867.9	26.8	878.6	26.9	889.4	27.0	900.2	27.2	11
12	911.1	27.3	922.1	27.5	933.1	27.6	944.1	27.7	955.3	27.9	966.4	28.0	977.7	28.1	989.0	28.3	1000.3	28.4	1011.7	28.6	12
13	1023.1	28.7	1034.7	28.8	1046.2	29.0	1057.8	29.1	1069.5	29.3	1081.2	29.4	1093.0	29.5	1104.9	29.7	1116.8	29.8	1128.7	30.0	13
14	1140.7	30.1	1152.8	30.2	1164.9	30.4	1177.1	30.5	1189.3	30.6	1201.6	30.8	1214.0	30.9	1226.4	31.1	1238.8	31.2	1251.3	31.3	14
15	1263.9	31.5	1276.5	31.6	1289.2	31.8	1301.9	31.9	1314.7	32.0	1327.5	32.2	1340.4	32.3	1353.4	32.5	1366.4	32.6	1379.5	32.7	15
16	1392.6	32.9	1405.8	33.0	1419.0	33.1	1432.3	33.3	1445.6	33.4	1459.0	33.6	1472.5	33.7	1486.0	33.8	1499.6	34.0	1513.2	34.1	16
17	1526.9	34.3	1540.6	34.4	1554.4	34.5	1568.2	34.7	1582.1	34.8	1596.1	35.0	1610.1	35.1	1624.1	35.2	1638.3	35.4	1652.4	35.5	17
18	1666.7	35.6	1681.0	35.8	1695.3	35.9	1709.7	36.1	1724.1	36.2	1738.7	36.3	1753.2	36.5	1767.8	36.6	1782.5	36.8	1797.2	36.9	18
19	1812.0	37.0	1826.9	37.2	1841.8	37.3	1856.7	37.5	1871.7	37.6	1886.8	37.7	1901.9	37.9	1917.1	38.0	1932.3	38.1	1947.6	38.3	19
20	1963.0	38.4	1978.4	38.6	1993.8	38.7	2009.3	38.8	2024.9	39.0	2040.5	39.1	2056.2	39.3	2071.9	39.4	2087.7	39.5	2103.5	39.7	20
21	2119.4	39.8	2135.4	40.0	2151.4	40.1	2167.5	40.2	2183.6	40.4	2199.8	40.5	2216.0	40.6	2232.3	40.8	2248.6	40.9	2265.0	41.1	21
22	2281.5	41.2	2298.0	41.3	2314.6	41.5	2331.2	41.6	2347.9	41.8	2364.6	41.9	2381.4	42.0	2398.2	42.2	2415.1	42.3	2432.1	42.5	22
23	2449.1	42.6	2466.1	42.7	2483.3	42.9	2500.4	43.0	2517.7	43.1	2535.0	43.3	2552.3	43.4	2569.7	43.6	2587.1	43.7	2604.7	43.8	23
24	2622.2	44.0	2639.8	44.1	2657.5	44.3	2675.2	44.4	2693.0	44.5	2710.9	44.7	2728.8	44.8	2746.7	45.0	2764.7	45.1	2782.8	45.2	24
25	2800.9	45.4	2819.1	45.5	2837.3	45.6	2855.6	45.8	2874.0	45.9	2892.4	46.1	2910.8	46.2	2929.3	46.3	2947.9	46.5	2966.5	46.6	25
26	2985.2	46.8	3003.9	46.9	3022.7	47.0	3041.5	47.2	3060.4	47.3	3079.4	47.5	3098.4	47.6	3117.5	47.7	3136.6	47.9	3155.8	48.0	26
27	3175.0	48.1	3194.3	48.3	3213.6	48.4	3233.0	48.6	3252.5	48.7	3272.0	48.8	3291.6	49.0	3311.2	49.1	3330.9	49.3	3350.6	49.4	27
28	3370.4	49.5	3390.2	49.7	3410.1	49.8	3430.1	50.0	3450.1	50.1	3470.1	50.2	3490.3	50.4	3510.4	50.5	3530.7	50.6	3551.0	50.8	28
29	3571.3	50.9	3591.7	51.1	3612.1	51.2	3632.7	51.3	3653.2	51.5	3673.8	51.6	3694.5	51.8	3715.2	51.9	3736.0	52.0	3756.9	52.2	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	11.1	4.5	11.2	9.0	11.4	13.6	11.5	18.2	11.7	22.9	11.8	27.7	11.9	32.5	12.1	37.3	12.2	42.2	12.4	0
1	47.2	12.5	52.2	12.6	57.3	12.8	62.5	12.9	67.7	13.1	72.9	13.2	78.2	13.3	83.6	13.5	89.0	13.6	94.5	13.8	1
2	100.0	13.9	105.6	14.0	111.2	14.2	116.9	14.3	122.7	14.4	128.5	14.6	134.3	14.7	140.2	14.9	146.2	15.0	152.2	15.1	2
3	158.3	15.3	164.5	15.4	170.7	15.6	176.9	15.7	183.2	15.8	189.6	16.0	196.0	16.1	202.5	16.2	209.0	16.4	215.6	16.5	3
4	222.2	16.7	228.9	16.8	235.7	16.9	242.5	17.1	249.3	17.2	256.2	17.4	263.2	17.5	270.2	17.6	277.3	17.8	284.5	17.9	4
5	291.7	18.1	298.9	18.2	306.2	18.3	313.6	18.5	321.0	18.6	328.5	18.8	336.0	18.9	343.6	19.0	351.2	19.2	358.9	19.3	5
6	366.7	19.4	374.5	19.6	382.3	19.7	390.2	19.9	398.2	20.0	406.2	20.1	414.3	20.3	422.5	20.4	430.7	20.6	438.9	20.7	6
7	447.2	20.8	455.6	21.0	464.0	21.1	472.5	21.2	481.0	21.4	489.6	21.5	498.2	21.7	506.9	21.8	515.7	21.9	524.5	22.1	7
8	533.3	22.2	542.2	22.4	551.2	22.5	560.2	22.6	569.3	22.8	578.5	22.9	587.7	23.1	596.9	23.2	606.2	23.3	615.6	23.5	8
9	625.0	23.6	634.5	23.8	644.0	23.9	653.6	24.0	663.2	24.2	672.9	24.3	682.7	24.4	692.5	24.6	702.3	24.7	712.2	24.9	9
10	722.2	25.0	732.2	25.1	742.3	25.3	752.5	25.4	762.7	25.6	772.9	25.7	783.2	25.8	793.6	26.0	804.0	26.1	814.5	26.2	10
11	825.0	26.4	835.6	26.5	846.2	26.7	856.9	26.8	867.7	26.9	878.5	27.1	889.3	27.2	900.2	27.4	911.2	27.5	922.2	27.6	11
12	933.3	27.8	944.5	27.9	955.7	28.1	966.9	28.2	978.2	28.3	989.6	28.5	1001.0	28.6	1012.5	28.8	1024.0	28.9	1035.6	29.0	12
13	1047.2	29.2	1058.9	29.3	1070.7	29.4	1082.5	29.6	1094.3	29.7	1106.2	29.9	1118.2	30.0	1130.2	30.1	1142.3	30.3	1154.5	30.4	13
14	1166.7	30.6	1178.9	30.7	1191.2	30.8	1203.6	31.0	1216.0	31.1	1228.5	31.2	1241.0	31.4	1253.6	31.5	1266.2	31.7	1278.9	31.8	14
15	1291.7	31.9	1304.5	32.1	1317.3	32.2	1330.2	32.4	1343.2	32.5	1356.2	32.6	1369.3	32.8	1382.5	32.9	1395.7	33.1	1408.9	33.2	15
16	1422.2	33.3	1435.6	33.5	1449.0	33.6	1462.5	33.8	1476.0	33.9	1489.6	34.0	1503.2	34.2	1516.9	34.3	1530.7	34.4	1544.5	34.6	16
17	1558.3	34.7	1572.2	34.9	1586.2	35.0	1600.2	35.1	1614.3	35.3	1628.5	35.4	1642.7	35.6	1656.9	35.7	1671.2	35.8	1685.6	36.0	17
18	1700.0	36.1	1714.5	36.2	1729.0	36.4	1743.6	36.5	1758.2	36.7	1772.9	36.8	1787.7	36.9	1802.5	37.1	1817.3	37.2	1832.2	37.4	18
19	1847.2	37.5	1862.2	37.6	1877.3	37.8	1892.5	37.9	1907.7	38.1	1922.9	38.2	1938.2	38.3	1953.6	38.5	1969.0	38.6	1984.5	38.8	19
20	2000.0	38.9	2015.6	39.0	2031.2	39.2	2046.9	39.3	2062.7	39.4	2078.5	39.6	2094.3	39.7	2110.2	39.9	2126.2	40.0	2142.2	40.1	20
21	2158.3	40.3	2174.5	40.4	2190.7	40.6	2206.9	40.7	2223.2	40.8	2239.6	41.0	2256.0	41.1	2272.5	41.2	2289.0	41.4	2305.6	41.5	21
22	2322.2	41.7	2338.9	41.8	2355.7	41.9	2372.5	42.1	2389.3	42.2	2406.2	42.4	2423.2	42.5	2440.2	42.6	2457.3	42.8	2474.5	42.9	22
23	2491.7	43.1	2508.9	43.2	2526.2	43.3	2543.6	43.5	2561.0	43.6	2578.5	43.8	2596.0	43.9	2613.6	44.0	2631.2	44.2	2648.9	44.3	23
24	2666.7	44.4	2684.5	44.6	2702.3	44.7	2720.2	44.9	2738.2	45.0	2756.2	45.1	2774.3	45.3	2792.5	45.4	2810.7	45.6	2828.9	45.7	24
25	2847.2	45.8	2865.6	46.0	2884.0	46.1	2902.5	46.2	2921.0	46.4	2939.6	46.5	2958.2	46.7	2976.9	46.8	2995.7	46.9	3014.5	47.1	25
26	3033.3	47.2	3052.2	47.4	3071.2	47.5	3090.2	47.6	3109.3	47.8	3128.5	47.9	3147.7	48.1	3166.9	48.2	3186.2	48.3	3205.6	48.5	26
27	3225.0	48.6	3244.5	48.8	3264.0	48.9	3283.6	49.0	3303.2	49.2	3322.9	49.3	3342.7	49.4	3362.5	49.6	3382.4	49.7	3402.2	49.9	27
28	3422.2	50.0	3442.2	50.1	3462.3	50.3	3482.5	50.4	3502.7	50.6	3522.9	50.7	3543.2	50.8	3563.6	51.0	3584.0	51.1	3604.5	51.2	28
29	3625.0	51.4	3645.6	51.5	3666.2	51.7	3686.9	51.8	3707.7	51.9	3728.5	52.1	3749.3	52.2	3770.2	52.4	3791.2	52.5	3812.2	52.6	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 25: SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	11.6	4.7	11.7	9.4	11.9	14.1	12.0	19.0	12.1	23.8	12.3	28.8	12.4	33.8	12.5	38.8	12.7	43.9	12.8	0
1	49.1	13.0	54.3	13.1	59.6	13.2	64.9	13.4	70.3	13.5	75.7	13.7	81.2	13.8	86.7	13.9	92.3	14.1	98.0	14.2	1
2	103.7	14.4	109.5	14.5	115.3	14.6	121.2	14.8	127.1	14.9	133.1	15.0	139.1	15.2	145.2	15.3	151.4	15.5	157.6	15.6	2
3	163.9	15.7	170.2	15.9	176.6	16.0	183.0	16.2	189.5	16.3	196.1	16.4	202.7	16.6	209.3	16.7	216.0	16.9	222.8	17.0	3
4	229.6	17.1	236.5	17.3	243.4	17.4	250.4	17.5	257.5	17.7	264.6	17.8	271.7	18.0	279.0	18.1	286.2	18.2	293.5	18.4	4
5	300.9	18.5	308.4	18.7	315.9	18.8	323.4	18.9	331.0	19.1	338.7	19.2	346.4	19.4	354.1	19.5	362.0	19.6	369.8	19.8	5
6	377.8	19.9	385.8	20.0	393.8	20.2	401.9	20.3	410.1	20.5	418.3	20.6	426.6	20.7	434.9	20.9	443.3	21.0	451.7	21.2	6
7	460.2	21.3	468.7	21.4	477.3	21.6	486.0	21.7	494.7	21.9	503.5	22.0	512.3	22.1	521.2	22.3	530.1	22.4	539.1	22.5	7
8	548.1	22.7	557.2	22.8	566.4	23.0	575.6	23.1	584.9	23.2	594.2	23.4	603.6	23.5	613.0	23.7	622.5	23.8	632.1	23.9	8
9	641.7	24.1	651.3	24.2	661.0	24.4	670.8	24.5	680.6	24.6	690.5	24.8	700.4	24.9	710.4	25.0	720.5	25.2	730.6	25.3	9
10	740.7	25.5	751.0	25.6	761.2	25.7	771.5	25.9	781.9	26.0	792.4	26.2	802.9	26.3	813.4	26.4	824.0	26.6	834.7	26.7	10
11	845.4	26.9	856.1	27.0	867.0	27.1	877.8	27.3	888.8	27.4	899.8	27.5	910.8	27.7	921.9	27.8	933.1	28.0	944.3	28.1	11
12	955.6	28.2	966.9	28.4	978.3	28.5	989.7	28.7	1001.2	28.8	1012.7	28.9	1024.3	29.1	1036.0	29.2	1047.7	29.4	1059.5	29.5	12
13	1071.3	29.6	1083.2	29.8	1095.1	29.9	1107.1	30.0	1119.1	30.2	1131.2	30.3	1143.4	30.5	1155.6	30.6	1167.9	30.7	1180.2	30.9	13
14	1192.6	31.0	1205.0	31.2	1217.5	31.3	1230.1	31.4	1242.7	31.6	1255.3	31.7	1268.0	31.9	1280.8	32.0	1293.6	32.1	1306.5	32.3	14
15	1319.4	32.4	1332.4	32.5	1345.5	32.7	1358.6	32.8	1371.7	33.0	1385.0	33.1	1398.2	33.2	1411.5	33.4	1424.9	33.5	1438.4	33.7	15
16	1451.9	33.8	1465.4	33.9	1479.0	34.1	1492.7	34.2	1506.4	34.4	1520.1	34.5	1534.0	34.6	1547.8	34.8	1561.8	34.9	1575.8	35.0	16
17	1589.8	35.2	1603.9	35.3	1618.1	35.5	1632.3	35.6	1646.6	35.7	1660.9	35.9	1675.3	36.0	1689.7	36.2	1704.2	36.3	1718.7	36.4	17
18	1733.3	36.6	1748.0	36.7	1762.7	36.9	1777.5	37.0	1792.3	37.1	1807.2	37.3	1822.1	37.4	1837.1	37.5	1852.1	37.7	1867.2	37.8	18
19	1882.4	38.0	1897.6	38.1	1912.9	38.2	1928.2	38.4	1943.6	38.5	1959.0	38.7	1974.5	38.8	1990.1	38.9	2005.7	39.1	2021.3	39.2	19
20	2037.0	39.4	2052.8	39.5	2068.6	39.6	2084.5	39.8	2100.4	39.9	2116.4	40.0	2132.5	40.2	2148.6	40.3	2164.7	40.5	2181.0	40.6	20
21	2197.2	40.7	2213.5	40.9	2229.9	41.0	2246.4	41.2	2262.9	41.3	2279.4	41.4	2296.0	41.6	2312.7	41.7	2329.4	41.9	2346.1	42.0	21
22	2362.9	42.1	2379.8	42.3	2396.8	42.4	2413.8	42.5	2430.8	42.7	2447.9	42.8	2465.1	43.0	2482.3	43.1	2499.6	43.2	2516.9	43.4	22
23	2534.3	43.5	2551.7	43.7	2569.2	43.8	2586.7	43.9	2604.3	44.1	2622.0	44.2	2639.7	44.4	2657.5	44.5	2675.3	44.6	2693.2	44.8	23
24	2711.1	44.9	2729.1	45.0	2747.1	45.2	2765.2	45.3	2783.4	45.5	2801.6	45.6	2819.9	45.7	2838.2	45.9	2856.6	46.0	2875.0	46.2	24
25	2893.5	46.3	2912.1	46.4	2930.7	46.6	2949.3	46.7	2968.0	46.9	2986.8	47.0	3005.6	47.1	3024.5	47.3	3043.4	47.4	3062.4	47.5	25
26	3081.0	47.7	3100.6	47.8	3119.7	48.0	3139.0	48.1	3158.2	48.2	3177.5	48.4	3196.9	48.5	3216.4	48.7	3235.9	48.8	3255.4	48.9	26
27	3274.1	49.1	3294.7	49.2	3314.4	49.4	3334.1	49.5	3354.0	49.6	3373.8	49.8	3393.8	49.9	3413.8	50.0	3433.8	50.2	3453.9	50.3	27
28	3474.1	50.5	3494.3	50.6	3514.6	50.7	3534.9	50.9	3555.3	51.0	3575.7	51.2	3596.2	51.3	3616.7	51.4	3637.3	51.6	3658.0	51.7	28
29	3678.7	51.9	3699.5	52.0	3720.3	52.1	3741.2	52.3	3762.1	52.4	3783.1	52.5	3804.1	52.7	3825.2	52.8	3846.4	53.0	3867.6	53.1	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 26; SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0 L.	.0 K.	.1 L.	.1 K.	.2 L.	.2 K.	.3 L.	.3 K.	.4 L.	.4 K.	.5 L.	.5 K.	.6 L.	.6 K.	.7 L.	.7 K.	.8 L.	.8 K.	.9 L.	.9 K.	c
0	0.0	12.0	4.8	12.2	9.7	12.3	14.7	12.5	19.7	12.6	24.8	12.7	29.9	12.9	35.1	13.0	40.3	13.1	45.6	13.3	0
1	50.9	13.4	56.3	13.6	61.8	13.7	67.3	13.8	72.9	14.0	78.5	14.1	84.1	14.3	89.9	14.4	95.7	14.5	101.5	14.7	1
2	107.4	14.8	113.4	15.0	119.4	15.1	125.4	15.2	131.6	15.4	137.7	15.5	144.0	15.6	150.2	15.8	156.6	15.9	163.0	16.1	2
3	169.4	16.2	176.0	16.3	182.5	16.5	189.1	16.6	195.8	16.8	202.5	16.9	209.3	17.0	216.2	17.2	223.1	17.3	230.0	17.5	3
4	237.0	17.6	244.1	17.7	251.2	17.9	258.4	18.0	265.6	18.1	272.9	18.3	280.3	18.4	287.7	18.6	295.1	18.7	302.6	18.8	4
5	310.2	19.0	317.8	19.1	325.5	19.3	333.2	19.4	341.0	19.5	348.8	19.7	356.7	19.8	364.7	20.0	372.7	20.1	380.8	20.2	5
6	388.9	20.4	397.1	20.5	405.3	20.6	413.6	20.8	421.9	20.9	430.3	21.1	438.8	21.2	447.3	21.3	455.9	21.5	464.5	21.6	6
7	473.1	21.8	481.9	21.9	490.7	22.0	499.5	22.2	508.4	22.3	517.4	22.5	526.4	22.6	535.4	22.7	544.6	22.9	553.7	23.0	7
8	563.0	23.1	572.2	23.3	581.6	23.4	591.0	23.6	600.4	23.7	610.0	23.8	619.5	24.0	629.1	24.1	638.8	24.3	648.5	24.4	8
9	658.3	24.5	668.2	24.7	678.1	24.8	688.0	25.0	698.0	25.1	708.1	25.2	718.2	25.4	728.4	25.5	738.6	25.6	748.9	25.8	9
10	759.3	25.9	769.7	26.1	780.1	26.2	790.6	26.3	801.2	26.5	811.8	26.6	822.5	26.8	833.2	26.9	844.0	27.0	854.8	27.2	10
11	865.7	27.3	876.7	27.5	887.7	27.6	898.8	27.7	909.9	27.9	921.1	28.0	932.3	28.1	943.6	28.3	954.9	28.4	966.3	28.6	11
12	977.8	28.7	989.3	28.8	1000.9	29.0	1012.5	29.1	1024.1	29.3	1035.9	29.4	1047.7	29.5	1059.5	29.7	1071.4	29.8	1083.4	30.0	12
13	1095.4	30.1	1107.4	30.2	1119.6	30.4	1131.7	30.5	1144.0	30.6	1156.2	30.8	1168.6	30.9	1181.0	31.1	1193.4	31.2	1206.0	31.3	13
14	1218.5	31.5	1231.1	31.6	1243.8	31.8	1256.5	31.9	1269.3	32.0	1282.2	32.2	1295.1	32.3	1308.0	32.5	1321.0	32.6	1334.1	32.7	14
15	1347.2	32.9	1360.4	33.0	1373.6	33.1	1386.9	33.3	1400.3	33.4	1413.7	33.6	1427.1	33.7	1440.6	33.8	1454.2	34.0	1467.8	34.1	15
16	1481.5	34.3	1495.2	34.4	1509.0	34.5	1522.8	34.7	1536.7	34.8	1550.7	35.0	1564.7	35.1	1578.8	35.2	1592.9	35.4	1607.1	35.5	16
17	1621.3	35.6	1635.6	35.8	1649.9	35.9	1664.3	36.1	1678.8	36.2	1693.3	36.3	1707.9	36.5	1722.5	36.6	1737.1	36.8	1751.9	36.9	17
18	1766.7	37.0	1781.5	37.2	1796.4	37.3	1811.4	37.5	1826.4	37.6	1841.4	37.7	1856.6	37.9	1871.7	38.0	1887.0	38.1	1902.2	38.3	18
19	1917.6	38.4	1933.0	38.6	1948.4	38.7	1964.0	38.8	1979.5	39.0	1995.1	39.1	2010.8	39.3	2026.5	39.4	2042.3	39.5	2058.2	39.7	19
20	2074.1	39.8	2090.0	40.0	2106.0	40.1	2122.1	40.2	2138.2	40.4	2154.4	40.5	2170.6	40.6	2186.9	40.8	2203.3	40.9	2219.7	41.1	20
21	2236.1	41.2	2252.6	41.3	2269.2	41.5	2285.8	41.6	2302.5	41.8	2319.2	41.9	2336.0	42.0	2352.8	42.2	2369.7	42.3	2386.7	42.5	21
22	2403.7	42.6	2420.8	42.7	2437.9	42.9	2455.1	43.0	2472.3	43.1	2489.6	43.3	2506.9	43.4	2524.3	43.6	2541.8	43.7	2559.3	43.8	22
23	2576.9	44.0	2594.5	44.1	2612.1	44.3	2629.9	44.4	2647.7	44.5	2665.5	44.7	2683.4	44.8	2701.4	45.0	2719.4	45.1	2737.4	45.2	23
24	2755.6	45.4	2773.7	45.5	2792.0	45.6	2810.2	45.8	2828.6	45.9	2847.0	46.1	2865.4	46.2	2884.0	46.3	2902.5	46.5	2921.1	46.6	24
25	2939.8	46.8	2958.5	46.9	2977.3	47.0	2996.2	47.2	3015.1	47.3	3034.0	47.5	3053.0	47.6	3072.1	47.7	3091.2	47.9	3110.4	48.0	25
26	3129.6	48.1	3148.9	48.3	3168.3	48.4	3187.7	48.6	3207.1	48.7	3226.6	48.8	3246.2	49.0	3265.8	49.1	3285.5	49.3	3305.2	49.4	26
27	3325.0	49.5	3344.8	49.7	3364.7	49.8	3384.7	50.0	3404.7	50.1	3424.8	50.2	3444.9	50.4	3465.1	50.5	3485.3	50.6	3505.6	50.8	27
28	3525.9	50.9	3546.3	51.1	3566.8	51.2	3587.3	51.3	3607.9	51.5	3628.5	51.6	3649.1	51.8	3669.9	51.9	3690.7	52.0	3711.5	52.2	28
29	3732.4	52.3	3753.4	52.5	3774.4	52.6	3795.4	52.7	3816.6	52.9	3837.7	53.0	3859.0	53.1	3880.2	53.3	3901.6	53.4	3923.0	53.6	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

TABLE XXXII.—BASE 27; SLOPE 1¼ TO 1. CU. YDS. PER 50 FT.

c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	12.5	5.0	12.6	10.1	12.8	15.2	12.9	20.4	13.1	25.7	13.2	31.0	13.3	36.4	13.5	41.8	13.6	47.2	13.8	0
1	52.8	13.9	58.4	14.0	64.0	14.2	69.7	14.3	75.4	14.4	81.2	14.6	87.1	14.7	93.0	14.9	99.0	15.0	105.0	15.1	1
2	111.1	15.3	117.2	15.4	123.4	15.6	129.7	15.7	136.0	15.8	142.4	16.0	148.8	16.1	155.2	16.2	161.8	16.4	168.4	16.5	2
3	175.0	16.7	181.7	16.8	188.4	16.9	195.2	17.1	202.1	17.2	209.0	17.4	216.0	17.5	223.0	17.6	230.1	17.8	237.2	17.9	3
4	244.4	18.1	251.7	18.2	259.0	18.3	266.4	18.5	273.8	18.6	281.2	18.8	288.8	18.9	296.4	19.0	304.0	19.2	311.7	19.3	4
5	319.4	19.4	327.2	19.6	335.1	19.7	343.0	19.9	351.0	20.0	359.0	20.1	367.1	20.3	375.2	20.4	383.4	20.6	391.7	20.7	5
6	400.0	20.8	408.4	21.0	416.8	21.1	425.2	21.2	433.8	21.4	442.4	21.5	451.0	21.7	459.7	21.8	468.4	21.9	477.2	22.1	6
7	486.1	22.2	495.0	22.4	504.0	22.5	513.0	22.6	522.1	22.8	531.2	22.9	540.4	23.1	549.7	23.2	559.0	23.3	568.4	23.5	7
8	577.8	23.6	587.2	23.8	596.8	23.9	606.4	24.0	616.0	24.2	625.7	24.3	635.4	24.4	645.2	24.6	655.1	24.7	665.0	24.9	8
9	675.0	25.0	685.0	25.1	695.1	25.3	705.2	25.4	715.4	25.6	725.7	25.7	736.0	25.8	746.4	26.0	756.8	26.1	767.2	26.2	9
10	777.8	26.4	788.4	26.5	799.0	26.7	809.7	26.8	820.4	26.9	831.2	27.1	842.1	27.2	853.0	27.4	864.0	27.5	875.0	27.6	10
11	886.1	27.8	897.2	27.9	908.4	28.1	919.7	28.2	931.0	28.3	942.4	28.5	953.8	28.6	965.2	28.8	976.8	28.9	988.4	29.0	11
12	1000.0	29.2	1011.7	29.3	1023.4	29.4	1035.2	29.6	1047.1	29.7	1059.0	29.9	1071.0	30.0	1083.0	30.1	1095.1	30.3	1107.2	30.4	12
13	1119.4	30.6	1131.7	30.7	1144.0	30.8	1156.4	31.0	1168.8	31.1	1181.2	31.2	1193.8	31.4	1206.4	31.5	1219.0	31.7	1231.7	31.8	13
14	1244.4	31.9	1257.2	32.1	1270.1	32.2	1283.0	32.4	1296.0	32.5	1309.0	32.6	1322.1	32.8	1335.2	32.9	1348.4	33.1	1361.7	33.2	14
15	1375.0	33.3	1388.4	33.5	1401.8	33.6	1415.2	33.8	1428.8	33.9	1442.4	34.0	1456.0	34.2	1469.7	34.3	1483.4	34.4	1497.2	34.6	15
16	1511.1	34.7	1525.0	34.9	1539.0	35.0	1553.0	35.1	1567.1	35.3	1581.2	35.4	1595.4	35.6	1609.7	35.7	1624.0	35.8	1638.4	36.0	16
17	1652.8	36.1	1667.2	36.2	1681.8	36.4	1696.4	36.5	1711.0	36.7	1725.7	36.8	1740.4	36.9	1755.2	37.1	1770.1	37.2	1785.0	37.4	17
18	1800.0	37.5	1815.0	37.6	1830.1	37.8	1845.2	37.9	1860.4	38.1	1875.7	38.2	1891.0	38.3	1906.4	38.5	1921.8	38.6	1937.2	38.8	18
19	1952.8	38.9	1968.4	39.0	1984.0	39.2	1999.7	39.3	2015.4	39.4	2031.2	39.6	2047.1	39.7	2063.0	39.9	2079.0	40.0	2095.0	40.1	19
20	2111.1	40.3	2127.2	40.4	2143.4	40.6	2159.7	40.7	2176.0	40.8	2192.4	41.0	2208.8	41.1	2225.2	41.2	2241.8	41.4	2258.4	41.5	20
21	2275.0	41.7	2291.7	41.8	2308.4	41.9	2325.2	42.1	2342.1	42.2	2359.0	42.4	2376.0	42.5	2393.0	42.6	2410.1	42.8	2427.2	42.9	21
22	2444.4	43.1	2461.7	43.2	2479.0	43.3	2496.4	43.5	2513.8	43.6	2531.2	43.8	2548.8	43.9	2566.4	44.0	2584.0	44.2	2601.7	44.3	22
23	2619.4	44.4	2637.2	44.6	2655.1	44.7	2673.0	44.9	2691.0	45.0	2709.0	45.1	2727.1	45.3	2745.2	45.4	2763.4	45.6	2781.7	45.7	23
24	2800.0	45.8	2818.4	46.0	2836.8	46.1	2855.2	46.2	2873.8	46.4	2892.4	46.5	2911.0	46.7	2929.7	46.8	2948.4	46.9	2967.2	47.1	24
25	2986.1	47.2	3005.0	47.4	3024.0	47.5	3043.0	47.6	3062.1	47.8	3081.2	47.9	3100.4	48.1	3119.7	48.2	3139.0	48.3	3158.4	48.5	25
26	3177.8	48.6	3197.2	48.8	3216.8	48.9	3236.4	49.0	3256.0	49.2	3275.7	49.3	3295.4	49.4	3315.2	49.6	3335.1	49.7	3355.0	49.9	26
27	3375.0	50.0	3395.0	50.1	3415.1	50.3	3435.2	50.4	3455.4	50.6	3475.7	50.7	3496.0	50.8	3516.4	51.0	3536.8	51.1	3557.2	51.2	27
28	3577.8	51.4	3598.4	51.5	3619.0	51.7	3639.7	51.8	3660.4	51.9	3681.2	52.1	3702.1	52.2	3723.0	52.4	3744.0	52.5	3765.0	52.6	28
29	3786.1	52.8	3807.2	52.9	3828.4	53.1	3849.7	53.2	3871.0	53.3	3892.4	53.5	3913.8	53.6	3935.2	53.8	3956.8	53.9	3978.4	54.0	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

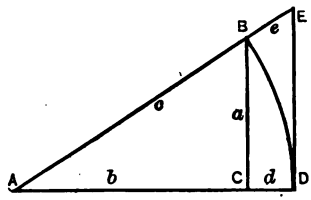
c	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		c
	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	L.	K.	
0	0.0	13.0	5.2	13.1	10.5	13.2	15.8	13.4	21.2	13.5	26.6	13.7	32.1	13.8	37.7	13.9	43.3	14.1	48.9	14.2	0
1	54.6	14.4	60.4	14.5	66.2	14.6	72.1	14.8	78.0	14.9	84.0	15.0	90.1	15.2	96.2	15.3	102.3	15.5	108.5	15.6	1
2	114.8	15.7	121.1	15.9	127.5	16.0	134.0	16.2	140.4	16.3	147.0	16.4	153.6	16.6	160.2	16.7	167.0	16.9	173.7	17.0	2
3	180.6	17.1	187.4	17.3	194.4	17.4	201.4	17.5	208.4	17.7	215.5	17.8	222.7	18.0	229.9	18.1	237.1	18.3	244.5	18.4	3
4	251.9	18.5	259.3	18.7	266.8	18.8	274.3	18.9	281.9	19.1	289.6	19.2	297.3	19.4	305.1	19.5	312.9	19.6	320.8	19.8	4
5	328.7	19.9	336.7	20.0	344.7	20.2	352.8	20.3	361.0	20.5	369.2	20.6	377.5	20.7	385.8	20.9	394.2	21.0	402.6	21.2	5
6	411.1	21.3	419.7	21.4	428.3	21.6	436.9	21.7	445.6	21.9	454.4	22.0	463.2	22.1	472.1	22.3	481.0	22.4	490.0	22.5	6
7	499.1	22.7	508.2	22.8	517.3	23.0	526.5	23.1	535.8	23.2	545.1	23.4	554.5	23.5	564.0	23.7	573.4	23.8	583.0	23.9	7
8	592.6	24.1	602.2	24.2	612.0	24.4	621.7	24.5	631.6	24.6	641.4	24.8	651.4	24.9	661.4	25.0	671.4	25.2	681.5	25.3	8
9	691.7	25.5	701.9	25.6	712.1	25.7	722.5	25.9	732.9	26.0	743.3	26.2	753.8	26.3	764.3	26.4	774.9	26.6	785.6	26.7	9
10	796.3	26.9	807.1	27.0	817.9	27.1	828.8	27.3	839.7	27.4	850.7	27.5	861.7	27.7	872.8	27.8	884.0	28.0	895.2	28.1	10
11	906.5	28.2	917.8	28.4	929.2	28.5	940.6	28.7	952.1	28.8	963.7	28.9	975.3	29.1	986.9	29.2	998.6	29.4	1010.4	29.5	11
12	1022.2	29.6	1034.1	29.8	1046.0	29.9	1058.0	30.0	1070.1	30.2	1082.2	30.3	1094.3	30.5	1106.5	30.6	1118.8	30.7	1131.1	30.9	12
13	1143.5	31.0	1156.0	31.2	1168.4	31.3	1181.0	31.4	1193.6	31.6	1206.2	31.7	1219.0	31.9	1231.7	32.0	1244.6	32.1	1257.4	32.3	13
14	1270.4	32.4	1283.4	32.5	1296.4	32.7	1309.5	32.8	1322.7	33.0	1335.9	33.1	1349.1	33.2	1362.5	33.4	1375.9	33.5	1389.3	33.7	14
15	1402.8	33.8	1416.3	33.9	1429.9	34.1	1443.6	34.2	1457.3	34.4	1471.1	34.5	1484.9	34.6	1498.8	34.8	1512.7	34.9	1526.7	35.0	15
16	1540.7	35.2	1554.8	35.3	1569.0	35.5	1583.2	35.6	1597.5	35.7	1611.8	35.9	1626.2	36.0	1640.6	36.2	1655.1	36.3	1669.7	36.4	16
17	1684.3	36.6	1698.9	36.7	1713.8	36.9	1728.4	37.0	1743.2	37.1	1758.1	37.3	1773.0	37.4	1788.0	37.5	1803.1	37.7	1818.2	37.8	17
18	1833.3	38.0	1848.5	38.1	1863.8	38.2	1879.1	38.4	1894.5	38.5	1910.0	38.7	1925.4	38.8	1941.0	38.9	1956.6	39.1	1972.2	39.2	18
19	1988.0	39.4	2003.7	39.5	2019.6	39.6	2035.4	39.8	2051.4	39.9	2067.4	40.0	2083.4	40.2	2099.5	40.3	2115.7	40.5	2131.9	40.6	19
20	2148.1	40.7	2164.5	40.9	2180.9	41.0	2197.3	41.2	2213.8	41.3	2230.3	41.4	2246.9	41.6	2263.6	41.7	2280.3	41.9	2297.1	42.0	20
21	2313.9	42.1	2330.8	42.3	2347.7	42.4	2364.7	42.5	2381.7	42.7	2398.8	42.8	2416.0	43.0	2433.2	43.1	2450.5	43.2	2467.8	43.4	21
22	2485.2	43.5	2502.6	43.7	2520.1	43.8	2537.7	43.9	2555.3	44.1	2572.9	44.2	2590.6	44.4	2608.4	44.5	2626.2	44.6	2644.1	44.8	22
23	2662.0	44.9	2680.0	45.0	2698.1	45.2	2716.2	45.3	2734.3	45.5	2752.5	45.6	2770.8	45.7	2789.1	45.9	2807.5	46.0	2826.0	46.2	23
24	2844.4	46.3	2863.0	46.4	2881.6	46.6	2900.2	46.7	2919.0	46.9	2937.7	47.0	2956.6	47.1	2975.4	47.3	2994.4	47.4	3013.4	47.5	24
25	3032.4	47.7	3051.5	47.8	3070.7	48.0	3089.9	48.1	3109.1	48.2	3128.5	48.4	3147.9	48.5	3167.3	48.7	3186.8	48.8	3206.3	48.9	25
26	3225.9	49.1	3245.6	49.2	3265.3	49.4	3285.1	49.5	3304.9	49.6	3324.8	49.8	3344.7	49.9	3364.7	50.0	3384.7	50.2	3404.8	50.3	26
27	3425.0	50.5	3445.2	50.6	3465.5	50.7	3485.8	50.9	3506.2	51.0	3526.6	51.2	3547.1	51.3	3567.7	51.4	3588.3	51.6	3608.9	51.7	27
28	3629.6	51.9	3650.4	52.0	3671.2	52.1	3692.1	52.3	3713.0	52.4	3734.0	52.5	3755.1	52.7	3776.2	52.8	3797.3	53.0	3818.5	53.1	28
29	3839.8	53.2	3861.1	53.4	3882.5	53.5	3904.0	53.7	3925.4	53.8	3947.0	53.9	3968.6	54.1	3990.2	54.2	4012.0	54.4	4033.7	54.5	29
	L.		L.		L.		L.		L.		L.		L.		L.		L.		L.		
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

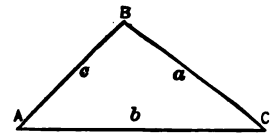
TABLE XXXII.—BASE 29: SLOPE 1½ TO 1. CU. YDS. PER 50 FT.

c	.0 L.	.0 K.	.1 L.	.1 K.	.2 L.	.2 K.	.3 L.	.3 K.	.4 L.	.4 K.	.5 L.	.5 K.	.6 L.	.6 K.	.7 L.	.7 K.	.8 L.	.8 K.	.9 L.	.9 K.	c
0	0.0	13.4	5.4	13.6	10.9	13.7	16.4	13.8	21.9	14.0	27.5	14.1	33.2	14.3	39.0	14.4	44.7	14.5	50.6	14.7	0
1	56.5	14.8	62.4	15.0	68.4	15.1	74.5	15.2	80.6	15.4	86.8	15.5	93.0	15.6	99.3	15.8	105.7	15.9	112.1	16.1	1
2	118.5	16.2	125.0	16.3	131.6	16.5	138.2	16.6	144.9	16.8	151.6	16.9	158.4	17.0	165.2	17.2	172.1	17.3	179.1	17.5	2
3	186.1	17.6	193.2	17.7	200.3	17.9	207.5	18.0	214.7	18.1	222.0	18.3	229.3	18.4	236.7	18.6	244.2	18.7	251.7	18.8	3
4	259.3	19.0	266.9	19.1	274.6	19.3	282.3	19.4	290.1	19.5	297.9	19.7	305.8	19.8	313.8	20.0	321.8	20.1	329.8	20.2	4
5	338.0	20.4	346.1	20.5	354.4	20.6	362.7	20.8	371.0	20.9	379.4	21.1	387.9	21.2	396.4	21.3	404.9	21.5	413.5	21.6	5
6	422.2	21.8	431.0	21.9	439.7	22.0	448.6	22.2	457.5	22.3	466.4	22.5	475.4	22.6	484.5	22.7	493.6	22.9	502.8	23.0	6
7	512.0	23.1	521.3	23.3	530.7	23.4	540.1	23.6	549.5	23.7	559.0	23.8	568.6	24.0	578.2	24.1	587.9	24.3	597.6	24.4	7
8	607.4	24.5	617.2	24.7	627.1	24.8	637.1	25.0	647.1	25.1	657.2	25.2	667.3	25.4	677.5	25.5	687.7	25.6	698.0	25.8	8
9	708.3	25.9	718.7	26.1	729.2	26.2	739.7	26.3	750.3	26.5	760.9	26.6	771.6	26.8	782.3	26.9	793.1	27.0	803.9	27.2	9
10	814.8	27.3	825.8	27.5	836.8	27.6	847.8	27.7	859.0	27.9	870.1	28.0	881.4	28.1	892.7	28.3	904.0	28.4	915.4	28.6	10
11	926.9	28.7	938.4	28.8	949.9	29.0	961.5	29.1	973.2	29.3	985.0	29.4	996.7	29.5	1008.6	29.7	1020.5	29.8	1032.4	30.0	11
12	1044.4	30.1	1056.5	30.2	1068.6	30.4	1080.8	30.5	1093.0	30.6	1105.3	30.8	1117.7	30.9	1130.1	31.1	1142.5	31.2	1155.0	31.3	12
13	1167.6	31.5	1180.2	31.6	1192.9	31.8	1205.6	31.9	1218.4	32.0	1231.2	32.2	1244.1	32.3	1257.1	32.5	1270.1	32.6	1283.2	32.7	13
14	1296.3	32.9	1309.5	33.0	1322.7	33.1	1336.0	33.3	1349.3	33.4	1362.7	33.6	1376.2	33.7	1389.7	33.8	1403.3	34.0	1416.9	34.1	14
15	1430.6	34.3	1444.3	34.4	1458.1	34.5	1471.9	34.7	1485.8	34.8	1499.8	35.0	1513.8	35.1	1527.8	35.2	1542.0	35.4	1556.1	35.5	15
16	1570.4	35.6	1584.7	35.8	1599.0	35.9	1613.4	36.1	1627.9	36.2	1642.4	36.3	1656.9	36.5	1671.5	36.6	1686.2	36.8	1701.0	36.9	16
17	1715.7	37.0	1730.6	37.2	1745.5	37.3	1760.4	37.5	1775.4	37.6	1790.5	37.7	1805.6	37.9	1820.8	38.0	1836.0	38.1	1851.3	38.3	17
18	1866.7	38.4	1882.1	38.6	1897.5	38.7	1913.0	38.8	1928.6	39.0	1944.2	39.1	1959.9	39.3	1975.6	39.4	1991.4	39.5	2007.2	39.7	18
19	2023.1	39.8	2039.1	40.0	2055.1	40.1	2071.2	40.2	2087.3	40.4	2103.5	40.5	2119.7	40.6	2136.0	40.8	2152.3	40.9	2168.7	41.1	19
20	2185.2	41.2	2201.7	41.3	2218.3	41.5	2234.9	41.6	2251.6	41.8	2268.3	41.9	2285.1	42.0	2301.9	42.2	2318.8	42.3	2335.8	42.5	20
21	2352.8	42.6	2369.8	42.7	2387.0	42.9	2404.1	43.0	2421.4	43.1	2438.7	43.3	2456.0	43.4	2473.4	43.6	2490.9	43.7	2508.4	43.8	21
22	2525.9	44.0	2543.5	44.1	2561.2	44.3	2579.0	44.4	2596.7	44.5	2614.6	44.7	2632.5	44.8	2650.4	45.0	2668.4	45.1	2686.5	45.2	22
23	2704.6	45.4	2722.8	45.5	2741.0	45.6	2759.3	45.8	2777.7	45.9	2796.1	46.1	2814.5	46.2	2833.0	46.3	2851.6	46.5	2870.2	46.6	23
24	2888.9	46.8	2907.6	46.9	2926.4	47.0	2945.2	47.2	2964.1	47.3	2983.1	47.5	3002.1	47.6	3021.2	47.7	3040.3	47.9	3059.5	48.0	24
25	3078.7	48.1	3098.0	48.3	3117.3	48.4	3136.7	48.6	3156.2	48.7	3175.7	48.8	3195.3	49.0	3214.9	49.1	3234.6	49.3	3254.3	49.4	25
26	3274.1	49.5	3293.9	49.7	3313.8	49.8	3333.8	50.0	3353.8	50.1	3373.8	50.2	3394.0	50.4	3414.1	50.5	3434.4	50.6	3454.7	50.8	26
27	3475.0	50.9	3495.4	51.1	3515.9	51.2	3536.4	51.3	3556.9	51.5	3577.5	51.6	3598.2	51.8	3619.0	51.9	3639.7	52.0	3660.6	52.2	27
28	3681.5	52.3	3702.4	52.5	3723.4	52.6	3744.5	52.7	3765.6	52.9	3786.8	53.0	3808.0	53.1	3829.3	53.3	3850.7	53.4	3872.1	53.6	28
29	3893.5	53.7	3915.0	53.8	3936.6	54.0	3958.2	54.1	3979.9	54.3	4001.6	54.4	4023.4	54.5	4045.2	54.7	4067.1	54.8	4089.1	55.0	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

c	.0 L.	.0 K.	.1 L.	.1 K.	.2 L.	.2 K.	.3 L.	.3 K.	.4 L.	.4 K.	.5 L.	.5 K.	.6 L.	.6 K.	.7 L.	.7 K.	.8 L.	.8 K.	.9 L.	.9 K.	c
0	0.0	13.9	5.6	14.0	11.2	14.2	16.9	14.3	22.7	14.4	28.5	14.6	34.3	14.7	40.2	14.9	46.2	15.0	52.2	15.1	0
1	58.3	15.3	64.5	15.4	70.7	15.6	76.9	15.7	83.2	15.8	89.6	16.0	96.0	16.1	102.5	16.2	109.0	16.4	115.6	16.5	1
2	122.2	16.7	128.9	16.8	135.7	16.9	142.5	17.1	149.3	17.2	156.2	17.4	163.2	17.5	170.2	17.6	177.3	17.8	184.5	17.9	2
3	191.7	18.1	198.9	18.2	206.2	18.3	213.6	18.5	221.0	18.6	228.5	18.8	236.0	18.9	243.6	19.0	251.2	19.2	258.9	19.3	3
4	266.7	19.4	274.5	19.6	282.3	19.7	290.2	19.9	298.2	20.0	306.2	20.1	314.3	20.3	322.5	20.4	330.7	20.6	338.9	20.7	4
5	347.2	20.8	355.6	21.0	364.0	21.1	372.5	21.2	381.0	21.4	389.6	21.5	398.2	21.7	406.9	21.8	415.7	21.9	424.5	22.1	5
6	433.3	22.2	442.2	22.4	451.2	22.5	460.2	22.6	469.3	22.8	478.5	22.9	487.7	23.1	496.9	23.2	506.2	23.3	515.6	23.5	6
7	525.0	23.6	534.5	23.8	544.0	23.9	553.6	24.0	563.2	24.2	572.9	24.3	582.7	24.4	592.5	24.6	602.3	24.7	612.2	24.9	7
8	622.2	25.0	632.2	25.1	642.3	25.3	652.5	25.4	662.7	25.6	672.9	25.7	683.2	25.8	693.6	26.0	704.0	26.1	714.5	26.2	8
9	725.0	26.4	735.6	26.5	746.2	26.7	756.9	26.8	767.7	26.9	778.5	27.1	789.3	27.2	800.2	27.4	811.2	27.5	822.2	27.6	9
10	833.3	27.8	844.5	27.9	855.7	28.1	866.9	28.2	878.2	28.3	889.6	28.5	901.0	28.6	912.5	28.8	924.0	28.9	935.6	29.0	10
11	947.2	29.2	958.9	29.3	970.7	29.4	982.5	29.6	994.3	29.7	1006.2	29.9	1018.2	30.0	1030.2	30.1	1042.3	30.3	1054.5	30.4	11
12	1066.7	30.6	1078.9	30.7	1091.2	30.8	1103.6	31.0	1116.0	31.1	1128.5	31.2	1141.0	31.4	1153.6	31.5	1166.2	31.7	1178.9	31.8	12
13	1191.7	31.9	1204.5	32.1	1217.3	32.2	1230.2	32.4	1243.2	32.5	1256.2	32.6	1269.3	32.8	1282.5	32.9	1295.7	33.1	1308.9	33.2	13
14	1322.2	33.3	1335.6	33.5	1349.0	33.6	1362.5	33.8	1376.0	33.9	1389.6	34.0	1403.2	34.2	1416.9	34.3	1430.7	34.4	1444.5	34.6	14
15	1458.3	34.7	1472.2	34.9	1486.2	35.0	1500.2	35.1	1514.3	35.3	1528.5	35.4	1542.7	35.6	1556.9	35.7	1571.2	35.8	1585.6	36.0	15
16	1600.0	36.1	1614.5	36.2	1629.0	36.4	1643.6	36.5	1658.2	36.7	1672.9	36.8	1687.7	36.9	1702.5	37.1	1717.3	37.2	1732.2	37.4	16
17	1747.2	37.5	1762.2	37.6	1777.3	37.8	1792.5	37.9	1807.7	38.1	1822.9	38.2	1838.2	38.3	1853.6	38.5	1869.0	38.6	1884.5	38.8	17
18	1900.0	38.9	1915.6	39.0	1931.2	39.2	1946.9	39.3	1962.7	39.4	1978.5	39.6	1994.3	39.7	2010.2	39.9	2026.2	40.0	2042.2	40.1	18
19	2058.3	40.3	2074.5	40.4	2090.7	40.6	2106.9	40.7	2123.2	40.8	2139.6	41.0	2156.0	41.1	2172.5	41.2	2189.0	41.4	2205.6	41.5	19
20	2222.2	41.7	2238.9	41.8	2255.7	41.9	2272.5	42.1	2289.3	42.2	2306.2	42.4	2323.2	42.5	2340.2	42.6	2357.3	42.8	2374.5	42.9	20
21	2391.7	43.1	2408.9	43.2	2426.2	43.3	2443.6	43.5	2461.0	43.6	2478.5	43.8	2496.0	43.9	2513.6	44.0	2531.2	44.2	2548.9	44.3	21
22	2566.7	44.4	2584.5	44.6	2602.3	44.7	2620.2	44.9	2638.2	45.0	2656.2	45.1	2674.3	45.3	2692.5	45.4	2710.7	45.6	2728.9	45.7	22
23	2747.2	45.8	2765.6	46.0	2784.0	46.1	2802.5	46.2	2821.0	46.4	2839.6	46.5	2858.2	46.7	2876.9	46.8	2895.7	46.9	2914.5	47.1	23
24	2933.3	47.2	2952.2	47.4	2971.2	47.5	2990.2	47.6	3009.3	47.8	3028.5	47.9	3047.7	48.1	3066.9	48.2	3086.2	48.3	3105.6	48.5	24
25	3125.0	48.6	3144.5	48.8	3164.0	48.9	3183.6	49.0	3203.2	49.2	3222.9	49.3	3242.7	49.4	3262.5	49.6	3282.3	49.7	3302.2	49.9	25
26	3322.2	50.0	3342.2	50.1	3362.3	50.3	3382.5	50.4	3402.7	50.6	3422.9	50.7	3443.2	50.8	3463.6	51.0	3484.0	51.1	3504.5	51.2	26
27	3525.0	51.4	3545.6	51.5	3566.2	51.7	3586.9	51.8	3607.7	51.9	3628.5	52.1	3649.3	52.2	3670.2	52.4	3691.2	52.5	3712.2	52.6	27
28	3733.3	52.8	3754.5	52.9	3775.7	53.1	3796.9	53.2	3818.2	53.3	3839.6	53.5	3861.0	53.6	3882.5	53.8	3904.0	53.9	3925.6	54.0	28
29	3947.2	54.2	3968.9	54.3	3990.7	54.4	4012.5	54.6	4034.3	54.7	4056.2	54.9	4078.2	55.0	4100.2	55.1	4122.3	55.3	4144.5	55.4	29
	.0		.1		.2		.3		.4		.5		.6		.7		.8		.9		

	Symbol.	Number.	Logarithm.
Ratio of circumference to diameter Area of circle (πr^2) radius = 1 Surface of sphere (πd^2) diam. = 1	π	3.14159	0.497150
Reciprocal of same	$\frac{1}{\pi}$	0.31831	9.502850
Area of circle $\left(\frac{\pi d^2}{4}\right)$ diameter = 1 . .	$\frac{1}{4}\pi$	0.78540	9.895090
Volume of sphere ($\frac{4}{3}\pi r^3$) radius = 1 .	$\frac{4}{3}\pi$	4.18879	0.622089
Area of sector of circle (length of arc = l)	$\frac{1}{2}lr$.		
Area of segment of parabola (c = chord; m = mid. ord.)	$\frac{2}{3}cm$.		
Area of segment of circle (ap.)	$\frac{2}{3}cm$.		
Base of hyperbolic logarithms	e	2.71828	0.434294
Modulus of common system of logs. = log e	M	0.43429	9.637784
Reciprocal of same = hyp. log. 10 . . .	$\frac{1}{M}$	2.30259	0.362216
Length of seconds pendulum at N. Y. (inches)		39.1017	1.592196
Acceleration due to gravity at New York	g	32.15949	1.507309
Cubic inches in 1 U. S. gallon		231	2.363612
Cubic inches in 1 Imperial gallon . . .		277.274	2.442909
U. S. gallons in 1 cubic foot		7.4805	0.873931
Imperial gallons in 1 cubic foot . . .		6.2321	0.794634
Feet in 1 meter		3.280833	0.515984
Inches in 1 meter		39.37	1.595165
Miles in 1 kilometer		0.62137	9.793350
Square feet in 1 square meter		10.7639	1.031968
Cubic feet in 1 cubic meter		35.3145	1.547953
Pounds (Av.) in 1 kilogram		2.20462	0.343334
Ton (2240 lbs.) in 1 tonne.		0.98421	9.993086
Ft.-lbs. in 1 kilogram-meter		7.23300	0.859318
Feet in 1 mile		5280	3.722634
Square feet in 1 acre		43560	4.639088





SOLUTION OF RIGHT TRIANGLES.

1. $\sin A=\frac{a}{c}=\cos B$
2. $\cos A=\frac{b}{c}=\sin B$
3. $\tan A=\frac{a}{b}=\cot B$
4. $\cot A=\frac{b}{a}=\tan B$
5. $\sec A=\frac{c}{b}=\operatorname{cosec} B$
6. $\operatorname{cosec} A=\frac{c}{a}=\sec B$
7. $\operatorname{vers} A=\frac{c-b}{c}=\frac{d}{c}$
8. $\operatorname{exsec} A=\frac{e}{c}$
9. $a=c\sin A=b\tan A=c\cos B=b\cot B=\sqrt{(c+b)(c-b)}$
10. $b=c\cos A=a\cot A=c\sin B=a\tan B=\sqrt{(c+a)(c-a)}$
11. $d=c\operatorname{vers} A$
12. $e=c\operatorname{exsec} A$
13. $c=\frac{a}{\cos B}=\frac{b}{\sin B}=\frac{a}{\sin A}=\frac{b}{\cos A}=\frac{d}{\operatorname{vers} A}=\frac{e}{\operatorname{exsec} A}$

SOLUTION OF OBLIQUE TRIANGLES.

Given.	Sought.	Formulas.
14. A, B, a	b, c	$b=\frac{a}{\sin A}\cdot\sin B,\quad c=\frac{a}{\sin A}\sin(A+B)$
15. A, a, b	B, c	$\sin B=\frac{\sin A}{a}\cdot b,\quad c=\frac{a}{\sin A}\cdot\sin C.$
16. C, a, b	$A-B$	$\tan\frac{1}{2}(A-B)=\frac{a-b}{a+b}\tan\frac{1}{2}(A+B)$
17. a, b, c	A	Let $s=\frac{1}{2}(a+b+c)$; $\sin\frac{1}{2}A=\sqrt{\frac{(s-b)(s-c)}{bc}}$
18.		$\cos\frac{1}{2}A=\sqrt{\frac{s(s-a)}{bc}}$; $\tan\frac{1}{2}A=\sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$
19.		$\sin A=\frac{2\sqrt{s(s-a)(s-b)(s-c)}}{bc}$;
20.		$\operatorname{vers} A=\frac{2(s-b)(s-c)}{bc}$
21.	area	$\text{area}=\sqrt{s(s-a)(s-b)(s-c)}$
22. A, B, C, a	area	$\text{area}=\frac{a^2\sin B\,.\sin C}{2\sin A}$
23. C, a, b	area	$\text{area}=\frac{1}{2}ab\sin C.$

GENERAL FORMULAS.

24. $\sin A = 2\sin \frac{1}{2}A \cos \frac{1}{2}A = \sqrt{1-\cos^2 A} = \tan A \cos A.$

25. $\cos A = 2\cos^2 \frac{1}{2}A - 1 = 1 - 2\sin^2 \frac{1}{2}A = \cos^2 \frac{1}{2}A - \sin^2 \frac{1}{2}A$

26. $\tan A = \dfrac{\sin A}{\cos A} = \dfrac{\sin 2A}{1+\cos 2A}.$

27. $\cot A = \dfrac{\cos A}{\sin A} = \dfrac{\sin 2A}{1-\cos 2A} = \dfrac{\sin 2A}{\operatorname{vers} 2A}$

28. $\operatorname{vers} A = 1 - \cos A = \sin A \tan \frac{1}{2}A = 2\sin^2 \frac{1}{2}A$

29. $\operatorname{exsec} A = \sec A - 1 = \tan A \tan \frac{1}{2}A = \dfrac{\operatorname{vers} A}{\cos A}$

30. $\sin 2A = 2\sin A \cos A$

31. $\cos 2A = 2\cos^2 A - 1 = \cos^2 A - \sin^2 A = 1 - 2\sin^2 A$

32. $\tan 2A = \dfrac{2\tan A}{1-\tan^2 A}$

33. $\cot 2A = \dfrac{\cot^2 A - 1}{2\cot A}$

34. $\operatorname{vers} 2A = 2\sin^2 A = 2\sin A \cos A \tan A$

35. $\operatorname{exsec} 2A = \dfrac{2\tan^2 A}{1-\tan^2 A}$

36. $\sin^2 A + \cos^2 A = 1$

37. $\sin(A \pm B) = \sin A \cdot \cos B \pm \sin B \cdot \cos A$

38. $\cos(A \pm B) = \cos A \cdot \cos B \mp \sin A \cdot \sin B$

39. $\sin A + \sin B = 2\sin \frac{1}{2}(A+B)\cos \frac{1}{2}(A-B)$

40. $\sin A - \sin B = 2\cos \frac{1}{2}(A+B)\sin \frac{1}{2}(A-B)$

41. $\cos A + \cos B = 2\cos \frac{1}{2}(A+B)\cos \frac{1}{2}(A-B)$

42. $\cos B - \cos A = 2\sin \frac{1}{2}(A+B)\sin \frac{1}{2}(A-B)$

43. $\sin^2 A - \sin^2 B = \cos^2 B - \cos^2 A = \sin(A+B)\sin(A-B)$

44. $\cos^2 A - \sin^2 B = \cos(A+B)\cos(A-B)$

45. $\tan A + \tan B = \dfrac{\sin(A+B)}{\cos A \cdot \cos B}$

46. $\tan A - \tan B = \dfrac{\sin(A-B)}{\cos A \cdot \cos B}$

SIMPLE CURVE FORMULAS.

(1) $\sin \frac{1}{2} D = \frac{50}{R}$

(2) $R = \frac{50}{\sin \frac{1}{2} D}$

(4) $R_a = \frac{5730}{D_a}$ (ap.)

(5) $T = R \tan \frac{1}{2} I$

(6) $T_a = \frac{T_1}{D_a}$ (ap.)

(7) $E = R \operatorname{exsec} \frac{1}{2} I$

(8) $E_a = \frac{E_1}{D_a}$ (ap.)

(9) $M = R \operatorname{vers} \frac{1}{2} I$

(10) $C = 2 R \sin \frac{1}{2} I$

(11) $R = T \cot \frac{1}{2} I$

(12) $R = \frac{E}{\operatorname{exsec} \frac{1}{2} I}$

(13) $R = \frac{M}{\operatorname{vers} \frac{1}{2} I}$

(14) $R = \frac{C}{2 \sin \frac{1}{2} I}$

(15) $D_a = \frac{5730}{R_a}$ (ap.)

(16) $D_a = \frac{T_1}{T_a}$ (ap.)

(17) $D_a = \frac{E_1}{E_a}$ (ap.)

(18) $c = 2 R \sin \frac{1}{2} d$

(19) $\frac{c}{100} = \frac{d}{D}$ (ap.)

(20) $d = \frac{cD}{100}$

(22) $\frac{d}{2} = c \times 0.3' \times D_a$ (min.)

(23) $L = 100 \frac{I}{D}$ (ap.)

(24) $I = \frac{LD}{100}$ (ap.)

(25) $D = \frac{100 I}{L}$

(26) $a = \frac{c^2}{2 R} \quad a_{100} = \frac{100^2}{2 R}$

(27) $a_{s-l} = a_1 (D_s - D_l)$

(28) $a_n = n^2 a_{100}$ (ap.)

(29) $a_l = a_{100} \frac{c_l^2}{100^2}$

(30) $c - a = \frac{h^2}{2c}$ (ap.) $= \frac{h^2}{2a}$ (ap

(31) $M = R - \sqrt{R^2 - \left(\frac{c}{2}\right)^2}$

(32) $M = R - \sqrt{\left(R - \frac{c}{2}\right)\left(R +$

(33) Ordinate $= \sqrt{(R+q)(R-q)} - \sqrt{\left(R + \frac{c}{2}\right)\left(R - \frac{c}{2}\right)}$

(34) $M = \frac{c^2}{8 R}$ (ap.)

(35) Offset $= \frac{q^2}{\left(\frac{c}{2}\right)^2} M$ (ap.)

(36) Ordinate $= \frac{AQ \times QB}{2 R}$ (ap.)

(37) $AA' = \frac{p}{\sin I}$

(38) $R - R' = \frac{p}{\operatorname{vers} I}$

(39) $BB' = \frac{p}{\sin \frac{1}{2} I}$

(40) $R - R' = \frac{p}{\operatorname{vers} I}$

(41) $R - R' = \frac{p}{\operatorname{exsec} I}$

(42) $AA' = (R - R') \tan I$

COMPOUND AND REVERSED CURVES.

(46) $\text{vers } I_t = \dfrac{T_s \sin I - R_s \text{ vers } I}{R_t - R_s}$

(47) $T_t = (R_t - R_s) \sin I_t + R_s \sin I - T_s \cos I$. **Also (49).**

(48) $R_t - R_s = \dfrac{T_s \sin I - R_s \text{ vers } I}{\text{vers } I_t}$

(50) $\tan \frac{1}{2} I_t = \dfrac{T_s \sin I - R_s \text{ vers } I}{T_t + T_s \cos I - R_s \sin I}$

(51) $R_t - R_s = \dfrac{T_t + T_s \cos I - R_s \sin I}{\sin I_t}$

(52) $\text{vers } I_s = \dfrac{R_t \text{ vers } I - T_t \sin I}{R_t - R_s}$

(53) $T_s = R_t \sin I - (R_t - R_s) \sin I_s - T_t \cos I$. **Also (55).**

(54) $R_t - R_s = \dfrac{R_t \text{ vers } I - T_t \sin I}{\text{vers } I_s}$

(56) $\tan \frac{1}{2} I_s = \dfrac{R_t \text{ vers } I - T_t \sin I}{R_t \sin I - T_t \cos I - T_s}$

(57) $R_t - R_s = \dfrac{R_t \sin I - T_t \cos I - T_s}{\sin I_s}$

(64) $\dfrac{p}{R_t - R_s} = \text{vers } I_2$

(65) $\dfrac{p}{R_t - R_s} = \text{vers } I_t' - \text{vers } I_t$

(66) $\dfrac{p}{R_t - R_s} = \text{vers } I_t - \text{vers } I_t'$

(67) $\dfrac{p}{R_t - R_s} = \text{vers } I_s - \text{vers } I_s'$

(68) $\dfrac{p}{R_t - R_s} = \text{vers } I_s' - \text{vers } I_s$

(69) $\text{vers } I_r = \dfrac{\frac{1}{2} p}{R}$ (70) $R = \dfrac{\frac{1}{2} p}{\text{vers } I_r}$

(72) $R = \dfrac{d^2}{4\,D}$ (74) $d = 2\sqrt{Rp}$.

(75) $R_1 + R_2 = \dfrac{p}{\text{vers } I_r}$ (76) $\text{vers } I_r = \dfrac{p}{R_1 + R_2}$

(81) $R = \dfrac{l}{\tan \frac{1}{2} I_A + \tan \frac{1}{2} I_B}$

(77) $\text{vers } I_2 = \dfrac{R_1 \text{ vers } I + T_1 \sin I}{R_1 + R_2}$

(78) $T_2 = T_1 \cos I + R_1 \sin I - (R_1 + R_2) \sin I_2$

(79) $\text{vers } I_1 = \dfrac{R_2 \text{ vers } I + T_2 \sin I}{R_1 + R_2}$

(80) $T_1 = T_2 \cos I + R_2 \sin I + (R_1 + R_2) \sin I_1$

PARABOLAS, TURNOUTS, AND SPIRALS.

(82) $y^2 = 4p'x$

(86) $a_1 = \frac{g - g'}{2n}$

(87) $n = \frac{g - g'}{p}$

(89) $\cot \frac{1}{2} F = 2n$

(91) $R + \frac{g}{2} = \frac{g - t - k \sin F}{2 \sin \frac{1}{2}(F+S) \sin \frac{1}{2}(F-S)}$

(93) $E_a = l + \frac{g - t - k \sin F}{\tan \frac{1}{2}(F+S)} + k \cos F + bn$

(105) $a = g - \left(R + \frac{g}{2}\right) \operatorname{vers} F$

(106) $y_a = \left(R + \frac{g}{2}\right) \sin F - h \cos F + nb$

(107) $a = g - \left(R + \frac{g}{2}\right) \operatorname{vers} F + h \sin F$

(110) $l = \frac{p - g - g \cos F}{\sin F}$

(111) $R_2 + \frac{g}{2} = \frac{p - g}{\operatorname{vers} F}$

(113) $R_2 + \frac{g}{2} = \frac{p - g - l \sin}{\operatorname{vers} F}$

(117) $E = 2gn$

(118) $R = 2gn^2$

(120) $\tan \frac{1}{2} O = \frac{(p-g)n}{R_m + \frac{p}{2}}$

(121) $R_2' - \frac{p}{2} = \frac{(p-g)}{\tan \frac{1}{2}(F+}$

(132) $\cos I_t = \frac{R_1 + a_1 - R_2 - a_2}{R_1 + R_2 + a_3}$

(140) $e = \frac{gv^2}{32 \cdot 2 R}$

(141) $R = \frac{R_c l_c}{l}$

(141 *A*) $\frac{D}{D_c} = \frac{l}{l_c}$

(142) $s = \frac{l^2}{2 R_c l_c}$

(143) $x = \frac{y^3}{6 R_c l_c}$

(144) $x = \frac{l^3}{6 R_c l_c}$

(145 *A*) $s_c = \frac{l_c D_c}{200}$

(146) $i = \frac{s}{3}$; $i_c = \frac{s_c}{3}$

(146 *A*) $i = i_c \left(\frac{l}{l_c}\right)^2$

(148) $q = y_c - R_c \sin s_c$

(148 *A*) $p = x_c - R_c \operatorname{vers} s_c$

(149) $T_s = q + T_c + p \tan \frac{1}{2} I$

(150) $h = \frac{p}{\cos \frac{1}{2} I}$

(150 *A*) $d = q + p \tan \frac{1}{2} I$

(151) $R_1 - R_2 + h = \frac{h + p}{\operatorname{vers} \frac{1}{2} I}$

(151 *A*) $d = q - (R_1 - R_2 + h) \sin$

(152) $R_1 - R_2 = \frac{p}{\operatorname{vers} (\frac{1}{2} I - I_1)}$

(152 *A*) $d = q - (R_1 - R_2) \sin$

EARTHWORK.

(153) $r_g = h_i - h_g$

(154) $r_{g_1} = r_{g_0} - g$

(155) $c = r_g - r_c$

(156) $d = \frac{1}{2}b + sc$

(157) $d_r = \frac{1}{2}b + sh_r$

(158) $V = \frac{A_0 + A_1}{2} \cdot l$

(160) $a = c(b + sc)$

(161) $A = \frac{c(d_l + d_r) + \frac{b}{2}(h_l + h_r)}{2}$

(162) $A = \left(c + \frac{b}{2s}\right)\frac{D}{2} - \frac{b^2}{4s}$

(163) $A = \frac{cb + f_r d_r + f_l d_l}{2}$

(163 *A*) $V = (A_0 + 4M + A_1)\frac{l}{6}$

(166) $C = \frac{l}{12}(b_1 - b_0)(h_1 - h_0)$

(167) $C = \frac{l}{12}(c_1 - c_0)(D_1 - D_0)$ (ft.)

(168) $C_{100} = \frac{1}{3.24}(c_1 - c_0)(D_1 - D_0)$ (yds.)

(169) $V_p = V_e - C$

(169 *A*) $V_{p_l} = \frac{l}{100}(V_{e_{100}} - C_{100})$

(173) $C = \left(\frac{b}{2} + sc\right)(h_r - h_l)(d_r + d_l) \times 0.00011\,D$ (yds.)

(174) $C = \left(\frac{b}{2} + sc\right)(h_r - h_l)(d_r + d_l)\frac{l_0 + l_1}{200} \times 0.00011\,D$ (yds.)

(176) $s_1 = \frac{f_l}{15}\left(d_l + p_l - \frac{b}{2}\right)^2$

(178) $s_8 = \frac{(f_l p_l + f_r p_r)b}{4}$

(179) $V = A\frac{h_1 + h_2 + h_3}{3}$

(180) $V = A\frac{h_1 + h_2 + h_3 + h_4}{4}$

(183) $V_t = A\frac{t_1 + 2t_2 + 3t_3 + 4t_4}{4}$

(186 *A*) $S = L + K(h_l + h_r - 2c)$

(185) $V = A\frac{h_1 + h_2 + h_3 + h_4}{4} + \frac{A}{3}\left(h_c - \frac{h_1 + h_2 + h_3 + h_4}{4}\right)$

(185 *A*) $V = A\frac{h_1 + h_2 + h_3 + h_4}{4} + \frac{A}{3}\left(h_m - \frac{h_1 + h_2}{2}\right)$

(187) $V_{e_{100}} = S_0 + S_1$

(188) $V_{e_l} = (S_0 + S_1)\frac{l}{100}$

(190) $V_{p_l} = (S_0 + S_1 - C)\frac{l}{100}$

(191) $S = \frac{50}{54}aB$

(204) $x_g = \frac{l^2}{12} \cdot \frac{A_1 - A_0}{V}$ (ft.)

(206) $x_{g_{100}} = \frac{100}{6} \cdot \frac{S_1 - S_0}{V}$

(207) $x_{g_l} = x_{g_{100}} \cdot \frac{l}{100}$

(208) $H - H_a = \frac{100}{6}(S_a - S_m)$

EXPLANATION OF TABLES.

For all Circular Curves except Metric Curves the degree ***D*** is the central angle subtended by a chord of 100 feet.

TABLE I. The Radius is computed from the Logarithm, and the latter is in general, therefore, superior in precision. A few of the large Radii at the beginning of this table are taken from ten-place tables and are superior in precision to the corresponding Logarithms. For many computations the Logarithms are more convenient than the Radii themselves.

TABLE II. Tangent Offsets and Middle Ordinates.
These are given for chords of 100 feet.

TABLE III. } Tangent Distances for a 1° Curve.
TABLE IV. } Correction for Tangent Distances.

The intersection angle I is marked by degrees at the top and minutes at the side. The tangent distance for a curve of any specified degree is obtained by taking from Table III. the tabular number for the given intersection angle, and dividing this by the specified degree of curve. This gives a result approximately correct. The correct result may be obtained by applying from Table IV. the correction for the specified degree of curve and the given intersection angle. This correction is to be added *after dividing* by the degree of curve.

Example. Degree = 9°. Intersection angle = 60° 48′.

Tabular number = 3361.6(9 = D.

373.51	approx. value T.
.38	= correction 9° and 61°.
373.9	= correct value for Tangent Distance.

TABLE V. External Distances for a 1° Curve.

For any specified degree, divide the tabular number by the specified degree of curve. The result is closely approximate. *No table of* corrections is given for this. Where definite precision *is required*, find result by logarithmic computation.

TABLE VI. Spirals for Various Degrees of Curve.

The spiral adopted here is the Am. Ry. Eng. Ass'n spiral in which the length of spiral is the sum of ten equal chords, and in which the spiral angles vary as the squares of the lengths from the *T.S.* The Am. Ry. Eng. Ass'n has computed values of y_e, x_e, C, in terms of the length of spiral l_e. These values have been used as the fundamental basis in computing the values of y_e, x_e, q, p, and the long chord C in this table. Lengths of spiral are here given in multiples of 20 feet for various degrees of curve from 1° to 20°. The values of s_e are also given in this table. For finding the deflection angles this value of s_e is used in Table VII immediately following.

TABLE VII. Deflection Angles for Spirals.

For the values of s_e found in Table VI or by other method, the ten deflection angles to chord points are given. However the spiral may have been selected, when s_e is determined, the values of the ten deflection angles are as found in this table.

TABLE VII A. Deflection Angles from Intermediate Points on Spirals.

For any given spiral when s_e is determined the first deflection angle i_1 is found in Table VII. When the transit is at any intermediate point Table VII A gives coefficients by which i_1 is to be multiplied when sighting at any chord point (forward or backward) used either as a backsight on an established point, or as a new point to be fixed on the spiral.

Example. Spiral angle $s_e = 8°36' = 8.6°$.

Table VII gives $i_1 = 0°01.72'$.

Transit at point 6

Back deflection to *T.S.* $= 01.72' \times 36 = 62'$
$= 1°02'$

Forward deflection to point 7 $= 01.72' \times 20 = 0°34'$
8 $= 01.72' \times 44 = 1°16'$
9 $= 01.72' \times 72 = 2°04'$
S.C. 10 $= 01.72' \times 104 = 2°59'$

There is a slight approximation in these coefficients but they are correct in ordinary cases and according to the Am. Ry. Eng. Ass'n in any case "if the central angle from the transit point to the point of sight, less the included angle from the *T.S.* to the transit point does not exceed 15°."

TABLE VII B. Spirals. Coefficients of x_c, y_c, p, q.

Ordinarily the spiral will be selected from Table VI and values of p and q taken from that table. In revising line irregular values of l_c and D_c will frequently be used. Table VII B allows values of p and q to be computed with little difficulty and x_c and y_c found if needed. The value of s_c can be found by ordinary computation.

TABLE VII C. Diagram for Length of Spirals.

This diagram explains itself.

TABLE VIII. Long Chords and Actual Arcs.

The actual arc for any given number of full stations may be found by multiplying the length of arc for one station by the number of stations. Actual arcs corresponding to sub-chords may be found by finding the angle and then multiplying the radius by the value taken from Table XX.

TABLE IX. Acres for Strip 100 Feet Wide.

The fractions of acres are carried to hundredths. The "Lengths in Feet" are the limits between which the acres (or fraction of acre) apply.

Example. How many acres in 1146.97 lineal feet? 1146.97 lies between 1143.45 and 1147.81, between which we find 2.63, the required number of acres.

TABLE X. Curves for Metric System.

This is computed on the basis that the Degree of Curve equals the Deflection Angle for a chord of 20 meters, or very nearly that the Degree of Curve is the central angle subtended by a chord of 10 meters or 1 station in length. The radius, the chord, length, offset, or other linear dimensions on the metric curve will be $\frac{2}{10}$ that of U.S. curves of double the degree or nearly $\frac{1}{10}$ those of U.S. curves of the same degree. The table shows the corresponding U.S. degree for each metric curve given.

TABLE XI. Barometric Tables.

The approximate difference in heights in feet is found by *taking the* difference between the tabular numbers correspond-

ing to the observed readings of the barometer in inches. Temperature correction is made by the formula $\frac{T+t-100}{1000}$ which is easily computed when necessary. The corrected difference in heights $D = (H-h)\left(1+\frac{T+t-100}{1000}\right)$ where H and T represent barometer and thermometer readings at one station and h, t, at the other.

Examples. Barometer Readings 29.83 28.17
Thermometer 75° 62°

Tabular number 28.17 2609
29.83 1049
1560

Temp. corr. $= \frac{75+62-100}{1000}$ $= \frac{37}{1000}$

1.037
1560
6222
5185
1037
1617.720

Diff. in height = 1618 ft.

TABLE XII. Logarithms of Numbers.

Where there are more than four significant figures, the table of proportional parts will be found useful. The star opposite certain logarithms shows that the two figures at the left are to be taken from the line below.

Example. Required log of 6723.46.

For left 672 and top 3 the logarithm = .827563 and diff. = 65.

Table of prop. parts 65 gives 26 for 4
4 for .6
3.827593

the characteristic 3 being one less than the number of significant figures to the left of the decimal point, in 6723.46.

Example. To find number for log 2.672962
Log of 4709 = .672929
33
Diff. = 92; for 3 prop. part = 28
5.
.5 prop. part = 4.6

Number is 470.935

TABLE XIII. Logarithmic Sines, Cosines, Tangents, and Cotangents.

In taking out degrees and minutes, use the minutes at the left with the degrees at the left, whether the degrees appear at top or at bottom of page; use the minutes at right in a similar way with the degrees at right. Use headings for Sin., Cos., Tan., Cot., as given at top with the degrees shown at top (whether right or left); use headings for Cos., Sin., Tan., Cot., as given at bottom with the degrees given at bottom (whether right or left). The difference for 1 second is given for every minute, and is to be multiplied by the number of seconds and the result added or subtracted.

For very small angles up to 5°, where results precise for the nearest second are required, Table XIV should be used.

TABLE XIV. Auxiliary Table for Logarithmic Sines and Tangents of Small Angles.

This table is computed upon the basis (approximately true) that the sines of small angles, or the tangents of small angles, are proportional to the angles themselves.

Example. Required log sin 0° 47′ 12″.

Then
$$\frac{\sin 47' 12''}{\sin 47'} = \frac{47' 12''}{47'}$$

$$\sin 47' 12' = 47' 12'' \frac{\sin 47'}{47'} = 2832'' \frac{\sin 47'}{2820''}$$

$$\begin{aligned} \log \sin \quad 47' &= 8.135810 \\ \log \quad 2820'' &= \underline{3.450249} \\ & \quad 4.685561 \\ \log \quad 2832'' &= \underline{3.452093} \\ \log \sin 47' 12'' &= 8.137654 \end{aligned}$$

This auxiliary table gives for 47′, shown in the example above, the value of log sin 47′ − log 2820″ = 4.685561 as appears above, and for each minute in similar fashion; the number given in the table, then, is to be added to the log of the *required angle* (given in seconds). It should be noted that *the table gives* the value of every minute in seconds. As above $47' = 2820''$; whence also $47' 12'' = 2832''$.

Example. Required angle whose log sin = 8.325327.
Log sin 1° 13′ is the nearest (Table XIII).

Required log sin	= 8.325327
Table XIV (sin) 1° 13′	= 4.685542
4363″ log	= 3.639785
or 1° 12′ 43″	= required angle.

Example. Required log sin 3° 19′ 34″.

Table XIV. value for 3° 19′ (sin)	= 4.685332
3° 20′	= 4.685330
Interpolate tabular value for 3° 19′ 34″	= 4.685331
Then log 11974″	= 4.078239
log sin 3° 19′ 34″	= 8.763570

TABLE XV. Logarithmic Versed Sines and External Secants.
No explanation appears necessary.

TABLE XVI. It may be shown that vers $A = 2\sin^2 \frac{1}{2} A$; it follows that for small angles it is approximately true that the versines of angles vary as the squares of the angles. The external secants also vary as the squares of the angles.

Example. $$\frac{\text{vers } 0^\circ 41' 17''}{\text{vers } 0^\circ 41'} = \frac{(0^\circ 41' 17'')^2}{(0^\circ 41')^2} = \frac{2477^2}{2460^2}$$

$$\text{vers } 0^\circ 41' 17'' = 2477^2 \frac{\text{vers } 0^\circ 41'}{2460^2}$$

The tabular number for 0° 41′	= log vers 0° 41′ − log 2460^2.
	= 9.070115
2 log 2477 = 3.393926 × 2	= 6.787852
log vers 0° 41′ 17″	= 5.857967

Example. Required angle whose log vers = 6.309065.
Log vers 1° 9′ is the nearest (Table XV.).

Required log vers	= 6.309065
Table XVI (vers) 1° 9′	= 9.070105
	7.238960(2
4164″ log	= 3.619480
or 1° 09′ 24″	= required angle

Similarly for external secants of small angles.

For exsec. of 90° − small angles, it may be shown that

$$\text{exsec } A = \frac{\text{vers } A}{\cos A}$$

$$\text{exsec } 90° - A = \frac{\text{vers } 90° - A}{\cos 90° - A} = \frac{\text{vers } 90° - A}{\sin A}$$

where sin A may be taken from auxiliary tables.

TABLE XVII. } Natural Sines and Cosines.
TABLE XVIII. }

Use the minutes at the left with the degrees at the top, and the minutes on the right with the degrees at the bottom.

TABLE XIX. Natural Versed Sines and External Secants.

This requires no explanation.

TABLE XX. Lengths of Circular Arcs; Radius = 1.

To find the arc for a given angle and given radius, look out the tabular number for the given degrees, also for the minutes, also for the seconds. Add these together and multiply by the radius. The result will be the length of arc.

TABLE XX A. Difference between Circular Arcs and Chords.

The table shows values for radius = 1. For any central angle, the tabular number is to be multiplied by the radius.

TABLE XXI. Squares, Cubes, Square Roots, Cube Roots, and Reciprocals.

This requires no explanation.

TABLE XXII. Turnouts and Switches.

The Frog Angles and Angles of Crotch Frog are good for any kind of turnout. The lead and length of switch rail are computed for Stub Switch only.

TABLE XXII A. }
XXII B. } Turnouts for Split Switches.

These tables are the standard tables of recommended practice of the Am. Ry. Eng. Ass'n. The combinations of frogs with *switches shown* in the table are a part of the standard recommended.

The table explains itself otherwise.

TABLE XXIII. Velocity Heights.

These are computed by the formula $H = 0.0355\ V^2$ which includes the effect due to the rotative energy of the wheels.

TABLE XXIV. Rise per Mile Various Grades.

TABLE XXV. Elevation of Outer Rail on Curves.

This table is based on the formula $e = \dfrac{gv^2D}{32.16 \times 5729.65}$

where $g = 4'8\frac{1}{2}''$

TABLE XXVI. Inches in Decimals of a Foot.

This table requires no special explanation.

TABLE XXVII. Middle Ordinate for Curving Rails.

This table gives in common fractions of an inch the middle ordinate for various lengths of rails. This will be more convenient for use than it would be if decimal fractions were to be used.

TABLE XXVIII. Stadia Reductions, Horizontal and Vertical.

Stadia hairs are set so that the horizontal distance with the line of sight level will be 100 times the rod reading, or $100\,r$.

To this, however, must be added a constant c, due to the optical construction of the instrument. It is common practice to assume that $c = 1$ ft. for transits, and $c = 2$ ft. for alidades. For a level sight the horizontal distance will be $100\,r + 1$ for transit, and this distance $100\,r + 1$ is also used in computing vertical heights, when a vertical angle has been taken.

Example. Rod reading = 5.27 at 7°37′; $c = 1$

$100\,r + 1 = 528$ for a transit

Vertical height from Table for rod reading of 1 ft. = 13.14

For rod reading 5.27 use corrected value $5.28 \times 13.14 = 69.4$

For horizontal correction, interpolate for 528 and for 7°37′ to nearest foot = 9

$100\,r + 1 = 528$

Horizontal distance = 519

TABLE XXIX. Mean refraction in Declination.

This table is copied from W. and L. E. Gurley's Manual by permission. The hour angle indicates the distance of the sun from the meridian; for example, 2 hours indicates either 10 A.M. or 2 P.M. For one hour either before or after noon the refraction may properly be taken the same as at noon, or o h.

Declinations north appear as + in the table, and the refraction is to be added. Similarly, declinations south appear as −, and refractions are to be subtracted. The refractions here given are to be applied to declinations taken from the Nautical Almanac, and a sufficient record of these must be made before going into the field.

Example. Required corrected declinations Monday, Sept. 11, 1905, at New Orleans. (Lat. 29° 57′ 46″; Long. $6^h\ 00^m\ 13.9^s$.)

Greenwich Mean Noon = 6 A.M. New Orleans (standard time).

Naut. Alm. gives Decl. N. or + 4° 43 16″, Diff. for 1 hour = 0′ 57″ (subtract).

Lat. 30°
Decl. + 5°

New Orleans	Declination		Refraction		for 5^h = 1′ 52″ 4^h = 0′ 52″
6 A.M.	+ 4° 43′ 16″				
	− 57″				
7	4° 42′ 19″	+	1′ 52″	=	4° 44′ 11″
	57″				
8	4° 41′ 22″	+	0′ 52″	=	4° 42′ 14″
9	4° 40′ 25″	+	0′ 39″	=	4° 41′ 04″
10	4° 39′ 28″	+	0′ 31″	=	4° 39′ 59′
11 A.M.	4° 38′ 31″	+	0′ 27″	=	4° 38′ 58″
12 M.	4° 37′ 34″	+	0′ 27″	=	4° 38′ 01″
1 P.M.	4° 36′ 37″	+	0′ 27″	=	4° 37′ 04″
2	4° 35 40″	+	0′ 31″	=	4° 36′ 11″
3	4° 34′ 43″	+	0′ 39″	=	4° 35′ 22″
4	4° 33′ 46″	+	0′ 52″	=	4° 34′ 38″
5	4° 32′ 49″	+	1′ 52″	=	4° 34′ 41″

Example. Required corrected declinations Monday, Feb. 6, 1905, at Denver. (Lat. 39° 45′ 00″; Long. 6ʰ 59ᵐ 58.2ˢ.)

Greenwich Mean Noon = 5 A.M. Denver (standard time).

Decl. S. or − 15° 43′ 46″ Diff. for 1 hour = 0′ 46″ (subtract).

Denver	Declination		Lat. 40° Decl. − 15° Refraction		
5 A.M.	− 15° 43′ 46″				for 5ʰ = 25′ 18″ (not suitable to use)
	46″				
6	15° 43′ 00″				for 4ʰ = 3′ 21″
	46″				for 3ʰ = 2′ 02″
7	15° 42′ 14″				
8	15° 41′ 28″	−	3′ 21″	=	15° 38′ 07″
9	15° 40′ 42″	−	2′ 02″	=	15° 38′ 40″
10	15° 39′ 56″	−	1′ 35″	=	15° 38′ 21″
11 A.M.	15° 39′ 10″	−	1′ 21″	=	15° 37′ 49″
12 M.	15° 38′ 24″	−	1′ 21″	=	15° 37′ 03″
1 P.M.	15° 37′ 38″	−	1′ 21″	=	15° 36′ 17″
2	15° 36′ 52″	−	1′ 35″	=	15° 35′ 17″
3	15° 36′ 06″	−	2′ 02″	=	15° 34′ 04″
4	15° 35′ 20″	−	3′ 21″	=	15° 31′ 59″

TABLE XXX. Triangular Prisms.

Any end area of a section of earthwork may be divided into a number of areas, each triangular in form. This table gives the solidity in cubic yards of a triangular prism 50 feet in length, the factors required for the table being the height or altitude a and the width or base B, in accordance with the formula $S = \frac{4}{81} aB$. The end area solidity for 100 feet in length, due to two different end sections, will be the sum of the two solidities for the end sections, or

$$V_{\cdot 100} = S_0 + S_1$$

Example. Sta. 1 $\frac{15.7}{-5.8} - 7.4 \frac{19.6}{-8.4}$

Base 14 ft.
Slope $1\frac{1}{2}$ to 1 0 $\frac{12.7}{-3.8} - 3.5 \frac{14.2}{-4.8}$

For Sta. 0 the calculation may be put in the form

$$S_0 = \tfrac{20}{54}(3.5 \times \overline{12.7 + 14.2}) + \tfrac{20}{54}(7.0 \times \overline{3.8 + 4.8})$$
$$= \tfrac{20}{54}(3.5 \times 26.9) \qquad + \tfrac{20}{54}(7.0 \times 8.6)$$

where the triangles are grouped in pairs, in which there is a common base for the two triangles in any pair.

Since the table is in the form $S = \frac{20}{54} aB$ the solidity for 20 will be 10 times that for 2, and the solidity for $\frac{2}{10}$ will be $\frac{1}{10}$ that for 2. The use of the table is then simple.

For instance, to find $\frac{20}{54}(19.3 \times 24.7)$, find

from Table XXX. 19.3

20.	=	357.4
4.	=	71.5
.7	=	12.5
S	=	441.4

In the example given by notes above,

$$S_0 = \tfrac{20}{54}(3.5 \times 26.9) + \tfrac{20}{54}(7.0 \times 8.6)$$

from Table XXX. 26.9

3.	=	74.7		
.5		12.5	87.2	
8.6	7.		55.7	142.9

$$S_1 = \tfrac{20}{54}(7.4 \times 35.3) + \tfrac{20}{54}(7.0 \times 14.2)$$

from Table XXX. 35.3

7.	=	228.8		
.4	=	13.1	241.9	
14.2	7.	=	92.0	333.9
$V_{100} = S_0 + S_1$	=			476.8

If the section be 80 feet long instead of 100, the correct result *will be* $476.8 \times 0.8 = 381.44$, and for any length in direct proportion.

Irregular sections of earthwork may also be divided into pairs of triangles, and each pair calculated for 50 feet in length by $S = \frac{50}{54} aB$. If divided into trapezoids the computation may still be put in the form $S = \frac{50}{54} aB$. In both these cases this table evidently applies.

Where speed is desired, each quantity may be taken from the table to the nearest yard only, and two or more parts added by mental arithmetic. The precision thus secured is generally superior to that of the field measurements, where a difference of 0.1 foot in the height of any cut or fill means, commonly, several yards difference in solidity.

TABLE XXXI. Prismoidal Correction.

This table gives the correction to be applied to the "end area" solidity to secure a result strictly correct by prismoidal formula. The table gives values for $C = \frac{1}{3.24}(c_1 - c_0)(D_1 - D_0)$. In this table also the correction for 20 will be 10 times that for 2, and the correction for $\frac{2}{10}$ will be $\frac{1}{10}$ that for 2.

Example. Use data given above for Table XXX (top p. 280). The correction will be

$$C = \frac{1}{3.24}(7.4 - 3.5)(\overline{19.6 + 15.7} - \overline{14.2 + 12.7})$$

$$= \frac{1}{3.24}(3.9)(35.3 - 26.9)$$

$$= \frac{1}{3.24}(3.9)(8.4)$$

from Table XXXI. 3.9 8. $= 9.63$

$.4 = .48$

10.11

From Example Table XXX, $V_{e_{100}} = 476.8$

from above $C = 10.1$

Correct Solidity $= V_{p_{100}} = 466.7$

If the section be 80 feet long instead of 100, the correct result will be $466.7 \times 0.8 = 373.36$ and for any length in direct proportion.

The multiplication by 0.8 can best be made, as just above, *after applying the correction.*

TABLE XXXII. Earthwork for various bases and for slope $1\frac{1}{2}$ to 1.

It applies only to regular "Three Level Sections." Each table gives for any center height two quantities under columns L or K. Column L gives the solidity in cubic yards of a level section 50 feet in length and of the given center height. Column K gives a quantity to be used in connection with the side heights. The figure from column K is to be multiplied by the difference between (a) the sum of the side heights, and (b) twice the center height, or $K(h_r + h_l - 2c)$ and the result is to be added or subtracted depending upon whether the arithmetical sum of the side heights is greater or less than twice the center height.

Example. Sta. 1 $\frac{15.7}{-5.8}$ -7.4 $\frac{19.6}{-8.4}$

Base 14 feet
Slope $1\frac{1}{2}$ to 1 Sta. 0 $\frac{12.7}{-3.8}$ -3.5 $\frac{14.2}{-4.8}$

Sta. 0	3.5 L = 124.8	K = 11.3	3.8 = h_l	
	18.1	1.6	4.8 = h_r	
	142.9	678	8.6	
		113	7.0 = $2c$	
		18.08	1.6	
Sta. 1	7.4 L = 344.0	K = 16.8	5.8	
	− 10.1	− 0.6	8.4	
	333.9	− 10.08	14.2	
			14.8	

$S_0 = 142.9$
$S_1 = 333.9$
$V_{100} = 476.8$

The results agree with those given for Table XXX. where the *notes* are the same.

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